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THESIS

PROJECTED MANPOWER REQUIREMENTS OF THE NEXT GENERATION U.S. NAVY DESTROYER

by

James B. Coe Jr.

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Thesis Co-Advisors: Gregory Hildebrandt
Patrick Parker

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James B. Coe Jr.
Lieutenant, United States Navy
B.A., University of Florida, 1987

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Author: ______________________________
James B. Coe Jr.

Approved by: ______________________________
Gregory Hildebrandt, Thesis Co-Advisor

____
Patrick Parker, Thesis Co-Advisor

______________________________ for
David R. Whipple, Chairman
Department of Systems Management

ABSTRACT

In this century destroyers have made up a large portion of the U.S. fleet and contributed to determining Navy-wide manpower requirements. Destroyers vary in mission and capabilities. Plans exist to begin development of the next generation destroyer (SC 21). The class is projected to begin construction in 2003. This study will project the ship-board manpower requirements and personnel costs based on historical trends, exploitable technology, and anticipated mission. Estimates will vary according to the degree that technology advances. Navy organizational constraints also effect manpower requirements and will be considered in the estimates. This study projects requirements based upon three scenarios involving technology and Navy practices.

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I. INTRODUCTION

A. DEFINITION

DESTROYER: Originally, this war ship was constructed as a torpedo boat destroyer. The ships were initially designed as an answer to small torpedo boats that came with the advent of motorized torpedoes. Over the years, they were built as small, high speed lightly armed, and unarmored jack of all trades. Because of their speed and versatility on the high seas, they deservedly became the favorite ship of surface officers. Destroyers come in various configurations for specific employment; which illustrates the design changes necessitated by constantly developing technology. The class has grown enormously in size while retaining the name destroyer. In the 1890's, the first torpedo boats displaced only about 100 tons. The first destroyers, commissioned around the turn of the century, were twice that size. By WWI destroyers displaced about 1,000 tons, torpedo boats had disappeared, and destroyers had taken on their functions of high speed surface attack and anti-submarine patrol. Larger destroyers were known for many years as destroyer leaders or (after WWII) frigates in U.S. Navy. The class took on anti-air warfare duties as escorts for carrier task forces. More recently, some of the destroyer leaders have been redesignated as cruisers, while other destroyer leaders were reclassified as destroyers. The name frigate has been relegated to smaller, slower, escort-type ships not suited for aircraft carrier escort functions. Sailors refer to individual destroyers in slang terms as a can or a tin can. (Noel and Beach, pp 91-92)

B. OBJECTIVES

Destroyers have historically made up a large portion of the U.S. fleet and contributed to determining Navy-wide manpower requirements. By 1998, given current construction and decommissioning rates, destroyers will be the most numerous surface combatants in the U.S. Navy (approximately 52 in number). Three classes of ships with different sensors and weapons will comprise the projected destroyer force: 18 ARLEIGH BURKE's (DDG 51), 4 KIDD's (DDG 993), and 30 SPRUANCE's (DD 963). These multi-purpose ship types vary in mission and capabilities. Plans exist to begin development of the next generation destroyer, Twenty First Century Combatant (SC 21), in 2003, with completion by 2010. (Huchting, p49) This study will project the manpower requirements of the next generation U.S. Navy destroyer based on historical trends, exploitable technology, and anticipated mission.

C. ORGANIZATION OF STUDY

This thesis involves six chapters. The first is the introduction. Chapter II includes a broad historical view of the destroyer: (a) ship characteristics, (b) weapon systems, (c) engineering, (d) ship control, and (e) communications all of which dictate the need for manpower. In Chapter III, vintage destroyers commissioned from 1960 through 1991 are analyzed to note the associated operating costs of selected ships with respect to manpower and missions. A projected list of design features and components of the SC 21 are introduced in Chapter IV highlighting the primary engineering, weapons, and operations systems. In Chapter V, the future manpower requirements and costs of SC 21 will be estimated. Chapter VI contains conclusions and recommendations from the results of the study. Manpower cost estimates will be projected over time using the Navy Billet Cost Factor model.

D. SCOPE AND LIMITATIONS

The SC 21 is still in the conceptual stages of design with current plans to begin acquisition and construction in the year 2003. (ibid.) Based upon several articles in the Naval Institute Proceedings and conversations with flag officers in the acquisition shops in the navy, the most prevalent current view is that the ship will be built on an ARLEIGH BURKE hull. Other ship types such as an AEGIS capable amphibious ship have been mentioned but do not appear to have much support. As for now, the actual type of ship is yet to be determined and many of the systems are still in the early stages of development. The assumption in this study is that SC 21 will be designed as a destroyer. Naval ship manning doctrine of a hierarchical "pyramid" personnel structure is also assumed in this study. "The rank structures which will be required by the design of the 21st century surface combatant must be pyramidal also. . . Ship's crews must include enough junior people to train and promote to become senior people." (CNO, 1988, p9) Representative ships of the five leading heterogeneous destroyer classes are reviewed to note discreet trends in manning requirements from ships commissioned between 1960 and 1992. Personnel cost estimates are based upon 1993 pay and benefits. The goal of this thesis is to provide a long range projection of manpower requirements for the SC 21.

E. BACKGROUND

As the shrinking Defense budget effects the military, leaders are looking for innovative means to reduce operating costs while maintaining or increasing combat effectiveness and readiness. Commercial industry has found success in exploiting new technology and reengineering the work place. A large portion of the Navy's operating budget is dedicated to

ships. Hundreds of personnel are required to operate and maintain each U.S. Navy warship. Personnel costs were the largest single expense in the Navy budget appropriation in fiscal year 1993 comprising 28% of the total Navy budget. (Congressional Quarterly, p570) Because of evolutionary technological improvements, certain naval manning requirements have gone down as new classes of destroyers have replaced old ones with similar capability and mission.

Information technology (IT) has recently undergone revolutionary changes in cost, capability, and availability. Almost no commercial firm has escaped the IT revolution. Some have only gained modestly by employing IT automation to replace manual tasks. Others have reaped tremendous returns by adapting their work places to exploit information technology. New ways of managing are permitting firms to reduce supervisory employees and cut overhead costs. This occurs because firms recognize new opportunities in which capital is cheaper than labor. Successful firms are continually optimizing the capital-labor mix in a rapidly changing world. Navy policy makers can stand to gain a foothold in the "the battle of the budget" by learning from industry and exploiting new IT opportunities which present opportunities to optimize the mix of manpower to weapons platforms. Merchant ships in the recent past have taken advantage of automation to reduce manning to compete economically. To what extent can the Navy reduce personnel costs as merchants have without degrading combat effectiveness?

The Navy budget is developed from perceived national security threats and the resulting foreign policy. Navy force structure is assessed and weapon platforms (capital) are procured to play the Navy's part in foreign policy. The

weapon platforms "create" the demand for manpower on ships and ashore.

> ... The navy uses the ship work load (the operational and maintenance tasks... in wartime) and staffing standards (the amount of time and skills needed to perform these tasks). (GAO, 1986, p2)

II. HISTORICAL PERSPECTIVE OF DESTROYERS

This chapter will review some of the major classes of destroyers that stand out in U.S. Navy history. It will introduce some of the ship systems and weapons that have been impacting enlisted and officer manning trends. The data employed for projecting next generation destroyer manning begin with ships commissioned in 1960. This chapter provides a background of systems used to arrive at the projections. Table 2-1, provided at the end of the chapter, briefly describes the major destroyers in service since the mid 1930's. Hopefully, this will provide the reader with a better background into destroyer systems that can impact manning decisions.

A. THE SHIP CLASSES

The first Navy destroyer, USS BAINBRIDGE (DD 1) was commissioned in 1903. With two 4 pound guns and two torpedo tubes, she was built to attack larger war ships. This first destroyer displaced 420 tons and used coal fired boilers with reciprocating engines for propulsion. The early ships were too tender for open ocean duty and had to return to port to refuel. Larger ships were built to allow better range and sea keeping abilities. Steam turbines replaced reciprocating engines and oil replaced coal as preferred fuel by 1910. (U.S. Naval History Division, p8) The evolutionary change in fuel would allow prolonged at-sea endurance, using underway replenishment techniques to transfer fuel, food, and ammunition also in 1910. (Fee, Naval Engineering and American Seapower, p80) In 1915, prior to U.S. involvement in World War I, congress first authorized mass producing destroyers in substitution for the more expensive capital warships (battleships and cruisers.) The resulting World War I vintage destroyers were known as "Flushdeckers" and were constructed

primarily to perform large scale torpedo attacks against capital warships. Five technical breakthroughs improved the destroyer's capability. Depth charges and primitive hydrophones gave the destroyers better capability against submarines. Gun directors, gyro-stabilization of the gun director, and the mechanical range keeper greatly improved destroyer gunfire effectiveness. The early U.S. destroyers proved successful as convoy escorts by providing smoke screens and defending against German U-boat attacks.

Their high length to beam ratio gave them improved range and speed needed for torpedo attack against capital war ships. However they were poorly suited for antisubmarine work where agility was needed. The average flushdecker had a wider 180-degree turning radius at higher speeds than did a contemporary battleship! (Reilly, p11)

By 1922, there were over 265 flushdeck destroyers in service, however the post war drawdown saw numbers reduced to approximately 101 by 1923 and no new destroyers were built until 1932. In the mean time an important but indirect combat escort mission however developed for destroyers with the advent of sea-based aviation as the Navy developed and operated aircraft carriers. This mission was as lifeguard for the carriers during aircraft launch and recovery operations.

The FARRAGUT (DD 348) class, "gold platers" as they were known in the fleet, comprised the next generation U.S. destroyer. These ships emphasized guns over torpedoes as the preferred weapon in surface engagements. Numerous technical advances were employed to enhance the weapon systems. Some of the "gold platers'" advanced features included electro-hydraulic gun mounts, longitudinal hull framing, and superheated steam boilers. The guns were 5inch 38 caliber, bigger than the WWI destroyers. Longitudinal hull framing was

employed (and still is) for strength. Superheated steam provides much more potential energy than non-superheated or "saturated steam" which meant that these destroyers were more powerful and faster than previous classes. Various types of radar were back fitted on several of the class in later years. Several other classes of destroyers followed and bore strong resemblances to the FARRAGUT class. These destroyers displaced from 1,500 to 1,850 tons to conform to the constraints of the 1921 Washington Naval Treaty which limited naval fleets in terms of ship numbers, types, and tonnage. The FARRAGUTs and follow-on ships, ninety seven in all, were authorized for the main purpose of providing employment to a depressed U.S. economy. (Reilly, p24) These prewar destroyers would serve in World War II and the surviving ships were decommissioning immediately after the war in the draw down. The FARRAGUT class and her derivatives had one recurring problem during the war, poor stability.

The FLETCHER (DD 445) class was the culmination of 1930's experimentation and trade-offs of weapons, stability, and speed. In 1940, there was a consensus in naval leadership which agreed to the importance of anti-air (AA) and anti-submarine defense capability for destroyers. The class was initially armed with five 5" 38 calibre dual purpose (AA and anti-surface) guns, one AA gun mount, anti-ship torpedoes, and depth charges. Wartime experience dictated increasing AA capability at the expense of one of the 5 inch guns. The FLETCHERs were back-fitted with the newly developed Combat Information Center (CIC), as well as radar, for centralized tactical decision making in fighting the ship beginning in 1943 as ships' schedules permitted. Following World War II, this destroyer class would see improvements in radar, fire control systems, and anti-submarine warfare (ASW) weaponry.

The FLETCHERs would see action in the Korean conflict and on into the 1960's.

The ALLEN M. SUMNER (DD 692) and GEARING (DD 710) classes were improvement on the FLETCHER design. The largest U.S. destroyers in the fleet in World War II, they displaced 2,200 tons and closely resembled the FLETCHER class profile. The GEARING class was slightly longer than the ALLEN M. SUMNER and also carried more fuel. Both classes were designed to carry radar and were built with a CIC. These ships (and the FLECTCHER's) used 600 psi steam propulsion which was more powerful than the "gold plater" engineering plants and proved reliable over the years. These ships saw similar postwar evolutionary weapon and sensor improvements as the FLETCHERs. "Given the huge estimated requirements for escorts in future war,the U.S. Navy was fortunate in having many large destroyers suitable for conversion." (Friedman, 1986, p46) Seventy nine GEARING, thirty three ALLEN M. SUMNER, and three FLETCHER class ships would be overhauled in two versions of the Fleet Rehabilitation and Modernization (FRAM) program in the early 1960's. This program updated the weapon systems by introducing ASW torpedoes and variable depth sonar. The mission of these destroyers had now transitioned from mainly surface combat to ASW escort duty. The longer GEARING class received the Anti-Submarine Rocket (ASROC). All of the FRAM ships were modified by adding a light weight flight deck and small hangar to support the Drone Anti-Submarine Helicopter (DASH.) DASH proved itself unreliable and was never actively employed in the fleet. FRAM I, funded for the GEARING class, was designed to add eight to ten years to the platforms. The ALLEN M. SUMNER and FLETCHER reduced scale FRAM II package was intended to extend the useful life of the remnants by five years. (Preston, pp 118, 119) The GEARING class would serve

in the active fleet longer than any other destroyer class, spanning from 1943 to the early 1980's.

The MITSCHER (DL 2) class destroyer "leaders" were built immediately following World War II to fill a perceived gap in the light cruiser force. These ships were larger than the destroyers of the war but smaller than cruisers, displacing approximately 4,500 tons. The MITSCHER class had similar firepower to the war time destroyers. They were armed with two 5" 54 calibre dual purpose guns, two 3" 70 calibre AA guns, ASW torpedoes, and weapon alfa (a rocket propelled ASW depth bomb.) This class utilized the first fully automatic, self loading 5 inch gun mounts. The MITSCHER class superstructures were constructed from aluminum while the hull remained steel to reduce topside weight and increase stability. 1200 psi steam was first introduced in this class of destroyer to allow for higher speeds than before. Unfortunately, the higher pressure steam posed many problems with maintenance and would hinder reliability. This class was also the first destroyer fitted with bow mounted sonar to enhance ASW capability. Two of the class received modifications for the tartar MK 13 anti-air warfare (AAW) guided missile weapon systems and were redesignated as guided missile destroyers in 1968 and 1969. In 1955 the designations DL and DLG were changed to frigate and guided missile frigate. In 1975 the designations reverted back to destroyer and guided missile destroyer.[1] (Polmar, 1993, p131)

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[1] In 1975, the term frigate replaced the designation for destroyer escort (DE and DEG), smaller and less capable than the destroyer in the U.S. Navy. The designations DE and DEG were replaced by FF and FFG as frigate nomenclature respectively. (Tarpgaard, pp 3, 4)

The FORREST SHERMAN (DD 931) class were built from 1953 to 1956 as the first post-war destroyer. Slightly larger than the GEARING class, the FORREST SHERMAN had improved weaponry compared to the earlier generations with three automatic 5" 54 calibre guns, torpedoes, and Hedgehog ASW mortars. In the 1960's several ships in this class underwent modifications to improve either their ASW or AAW capabilities against the respective increased threats. Unfortunately, the FORREST SHERMAN's were constructed at a time when submarine and jet aircraft made them all but obsolete. Eight of the class received ASROC in place of their second 5 inch gun mount. Four of the class were converted to guided missile destroyers by replacing the second 5 inch gun mount with a MK 13 Tartar missile launcher and associated support equipment. The last DD 931 class ship was decommissioned in 1988 marking an end of an era. The FORREST SHERMAN class was the last class of U.S. destroyer built to conduct surface combat primarily against other surface ships within the horizon on the high seas.

The first U.S. destroyers built specifically as guided missile ships were the COONTZ (DDG 37, ex DLG 6) class in 1960 and 1961. These ships were modeled after the MITSCHER class destroyer leader. The largest destroyers built prior to 1973, they displaced 6150 tons at full load. The class had one 5 inch 54 calibre gun, two 3 inch 50 calibre AAW guns (later removed), torpedoes, ASROC, and MK 10 Mod 0 terrier missile launcher. The missiles were later modified to Standard missiles. The COONTZ class possessed more sensors than any previous destroyer with two surface search radars, two air search radars, two keel mounted sonar (PAIR), 3 fire control radars, and electronic warfare sensors. The Naval Tactical Data System (NTDS) was first tested aboard two COONTZ class ships in 1961 and 1962. By 1977 all ten members of the class

had received AAW modernization and NTDS. The last COONTZ class ship was decommissioned in the spring of 1994.

To counter increased threats from longer ranged threats from nuclear submarines and jet aircraft, the CHARLES F. ADAMS (DDG 2) class guided missile destroyers were based on an improved FORREST SHERMAN design. The class displaced 4825 tons at full load. They were fitted with the tartar missile system, ASROC, torpedoes and two 5 inch 54 calibre guns. Twenty three ADAMS class were commissioned from 1961 to 1964. DDG 2 through DDG 14 possessed the MK 11 Mod 0 twin armed missile launcher. DDG 15 through DDG 24 employed the MK 13 single arm missile launcher. Both systems had the same firing rates and were later upgraded to launch the Standard missile. All of the ships received extensive electronic countermeasures suites and modernized 3-d air search radars. The ADAMS class are the last generation of steam powered U.S. destroyer built. The final ship of the class was decommissioned in the spring of 1993.

The SPRUANCE (DD 963) class represent the "new look" of the U.S. Navy destroyer. First commissioned in 1975, the class was designed specifically for ASW. Designed as replacement for the GEARING (DD 710) and ALLEN M. SUMNER (DD 692) classes, the SPRUANCE class was initially armed with two 5 inch 54 calibre guns, ASROC, torpedoes, light airborne multi purpose system (LAMPS) helicopters, and the basic point defense missile system (BPDMS). At 8040 tons, these ships are over twice the displacement of most World War II vintage destroyers and employ vast technical improvements over previous classes in terms of engineering, stability, acoustic signature, and excess space for later addition of weapon systems. This class is also the first large U.S. combatant to extensively use gas turbines for propulsion and power

generation. Automation has been used in more systems than before allowing crew reduction over previous ships of similar size and capability. Initially, the class was heavily criticized for having relatively limited fire power compared to other contemporary destroyers. Since then, the Vulcan Phalanx close in weapon system (CIWS) and Harpoon anti-ship missiles have been installed aboard all SPRUANCE class ships. Beginning in the 1980's, the class received added firepower with the addition of the Tomahawk anti-ship missile/Tomahawk land attack missile (TASM/TLAM). Twenty four of the ships received the MK 41 Mod 1 vertical launching system (VLS) which has the capacity 61 missiles (TASM, TLAM, or ASROC). The other seven ships of the class have eight TASM/TLAM in armored box launchers (ABL) located topside. The SPRUANCE class features updated electronic systems, bow mounted sonar, tactical towed array sonar (TACTAS), air search radar (2-d), gun fire control radar, electronic warfare (EW) sensors, and NTDS.

The KIDD (DDG 993) class comprises four ships very similar to the SPRUANCE class in appearance. This class was originally built for the Shah of Iran as AAW platforms from the SPRUANCE design. The U.S. government appropriated funding to purchase the ships in 1979 after Iran canceled the order. Commissioned in 1981, these ships appear almost identical to the DD 963 class except for their two air search radars, missile fire control radar, and two MK 26 twin armed surface to air missile launchers fore and aft. Designed for operations in the Persian Gulf, they were built with increased air conditioning capacity and have dust filters over all air intakes. They have similar attributes to the SPRUANCE class with respect to ASW capability, Harpoon missiles, CIWS, and LAMPS. The only ASW sensor which the class lacks capability is

TACTAS. The KIDD class has missile capacity for 68 medium range Standard surface to air missiles and displaces 9574 tons at full load.

The newest addition to the U.S. destroyer ranks is the ARLIEGH BURKE (DDG 51) class. These are the first post World War II destroyers built with steel superstructures. They also have 130 tons of kevlar armor plating to protect vital spaces and sport partial chemical-biological-radiological (CBR) protection, a first for U.S. warships. The ARLIEGH BURKE class was built to enhance fleet air defense using the Aegis air defense system. They have a similar engineering plant to the SPRUANCE and KIDD classes but a different top side silhouette. The top side difference is that the air search radar faces are mounted on the forward superstructure instead of a rotating dish mounted on a mast aft of the forward superstructure. Shorter and wider than her two immediate predecessors, ARLIEGH BURKE was built to produce a smaller radar cross-section and allow for more firepower. Armament aboard the DDG 51 class includes fore and aft VLS (90 cells) with the capability of launching Standard surface to air missiles, TASM/TLAM, ASROC, 8 Harpoon launchers, torpedoes, one 5 inch 54 calibre gun, and CIWS. Sensors include the SPY-1(D) multi-function radar, bow mounted sonar, TACTAS, surface search radar, EW receivers, and the MK 99 Aegis fire control system. These ships displace 8422 tons at full load. The first of the class was commissioned in 1992 and is tentatively scheduled to remain in production through 1998. Beginning with DDG 68, the class will receive Joint Tactical Information Distribution System (JTIDS) and Tactical Data Information Exchange Subsystem (TADIX) which will increase tactical decision communication and decision making capabilities. An upgraded EW suite and improved surface to air missile will be

added to broaden the air defense envelope. These later ships will also have the ability to refuel and rearm LAMPS helicopters.

B. MANPOWER AND WEAPON SYSTEMS RELATIONSHIPS

The past thirty years have seen many naval technical evolutionary developments in weapon systems which have carried over into destroyer manpower requirements. These developments have improved combat effectiveness and permitted capital to be substituted for personnel. Automated gun mounts were the first fully exploited technology aboard destroyers to allow substitution. Brought about in the 1950's, this evolutionary change saw firing rates and weapon accuracy increase. The early automated gun mounts allowed local control of the mount in the event of gun director control failure. Gun mounts continued to evolve in terms of automation and personnel reduction. Current Navy guns employed in the destroyer fleet are fully automated and require drastically smaller crews than in the past.

Fire control systems evolved beginning in World War I to improve gun fire accuracy. The U.S. first capitalized on targeting developments in 1942 with the MK 56 gun fire control system that proliferated throughout the destroyer force. The system was designed for use against (non-maneuvering) subsonic aircraft and surface targets. Fire control systems have replaced marksmen on the gun mounts. Fire control systems over the years have absorbed operators as the gun mounts have seen losses. These systems perform guidance functions for missiles that have become the primary air defense mechanism in the past thirty years. Computer operated fire control systems aboard ship have not yet seen a decrease in manpower requirements for several reasons, but the potential is there. Warriors have realized that there is greater utility in

having more fire control capability than just adding more weapons for the sake of having more weapons.

Missile systems have traditionally not required as many persons to operate as gun systems. All U.S. Navy destroyers with operational guided missile systems were designed with fully automated launching systems. The tactical crews in monitoring missile preparation during launch have hovered around three persons until the arrival of the vertical launch system (VLS.) With VLS proliferating, the only real need for guided missile technicians is to perform preventive and corrective maintenance.

Radar has evolved and seen increased requirements for personnel to maintain, operate, and monitor. A necessary input for all major surface and air fire control systems, radar has expanded from two dimensional (range and bearing) to three dimensional (range, bearing, and altitude.) The newest and most advanced radars are phased array (fixed) and provide continual 360 degree coverage to assess the threat environment. Radars are very complex systems that consist of sender/receiver antennae, display monitors, power supplies, and data distribution devices. Currently, ships must carry several types of radar to perform different functions whether navigation, surface search, air search, or fire control. The electronic and IT revolutions have yielded vast improvements in radar effectiveness. Physics has not allowed using an all purpose radar to perform all destroyer missions. To maintain military flexibility, destroyers employ many different radars. They have a formidable maintenance and monitoring requirement which have seen increases in manpower. IT has the potential to reduce the current need of radar display observers significantly.

Electronic warfare (EW) was first employed by blocking enemy radio transmissions by "jamming" signals. EW has increased in sophistication over the years. In the U.S. Navy EW consists of electronic support measures (ESM), electronic countermeasures (ECM), and electronic counter-countermeasures (ECCM). ESM equipment consists primarily of receiver antennae and the supporting computers that process and identify the signals. ECM equipment is composed of chaff (radar reflective material) launchers. The chaff will present a radar cross-section hopefully more seductive to enemy fire control or missile terminal homing radar to evade impact. The DD 963 class ships have an added capacity with high frequency direction finding (HFDF) interception and identification equipment that increases manpower requirements over the other platforms. Current fleet EW equipment is not labor intensive compared to radar and does not require much in terms of operation or maintenance personnel requirements.

ASW has been in destroyer vocabulary since World War I. All U.S. destroyers since the 1930's have used some form of sonar and under sea weapons. Arguably, the most valuable asset added to surface ship ASW capabilities is the light airborne multipurpose system (LAMPS.) LAMPS is the integration of ship surveillance equipment: bow mounted sonar, tactical towed array sonar (TACTAS), and ASW equipped helicopters. The system can analyze submarine data from many sources and interpret to provide near real time submarine targeting solutions for fire control using either helicopter or ship borne weapons. LAMPS was first employed in the 1970's. The largest ASW requirements in manpower involve the helicopter and launching and recovering the TACTAS. Torpedo maintenance is low and launching is highly automated. Sonar

systems have similar observation and maintenance requirements to radar except that the sensors are submerged.

The personnel trends in the weapon systems dimension of destroyers show people shifting from ammo handling on the gun mounts and the depth charge racks to monitoring radar scopes and weapon consoles. Generally, the labor routines have shifted from primarily operating weapons topside to maintaining them from within the skin of the ship. In terms of long-range fire power, today's destroyers are more formidable than ever before.

C. MANPOWER TRENDS IN ENGINEERING SYSTEMS

The predominating naval engineering systems that involved manpower changes over the years centered in the propulsion and power generation systems. Coal fired boilers had proliferated in the navy since discovering the utility of steam in the nineteenth century until 1909. Naval engineers discovered in underway experiments that fuel oil was more efficient than coal, yielded greater power, and required fewer men to operate. John J. Fee quoted several articles dated in 1909 and 1911 from the American Society of Naval Engineers Journal:

> In a 24-hour period, 13.7 tons of fuel oil were used, in comparison with earlier trials where 30 tons of coal were needed. Moreover, the 8-knot speed of the VENUS using coal was increased to 11.75 knots using oil. . . Fewer men and equipment were necessary when fuel oil was used for heating boilers. Oil was pumped to the boilers, unlike coal that had to be moved by hand from coal bunkers by stokers. A one-third reduction in boiler tenders, one of the most undesirable and dangerous jobs on a ship, was achieved. (Fee, Naval Engineering and American Seapower, 1989)

By 1960, after many years of experimentation, 1200 psi steam boilers had replaced 600 and 800 psi as the power plant

of choice destroyer ship builders. Steam plants aboard navy ships are rather complex and as a thumb rule consist of the following equipment:

> Propulsion boilers, propulsion turbines, condensers, reduction gears, pumps, forced draft blowers, deairating feed tanks, and other auxiliary machinery units that directly serve the major propulsion units. Turbo-generators and their auxiliary condensers are usually located in the propulsion spaces . . . (Jolliff and Robertson, p18)

The steam destroyers used diesel generators for emergency power in the event of electric plant failure. These "emergency generators" were usually located in a remote auxiliary space away from the main engineering spaces.

In the 1950's, engineers developed and implemented automatic combustion control systems to maintain boilers at 1200 psi and 950 degrees F under all operating conditions using low pressure air and pneumatically controlled valves. "By 1972, combustion controls had become a reliable standard feature of all steam plants." (Barnes, Naval Engineering and American Seapower, 1989, p285) The controls greatly reduced the number of operators to operate the steam plant under normal conditions. In the event of a "control air" casualty, personnel had to operate the valves by hand.

> Marine power plants are unquestionably headed in the direction of greater reliability, improved maintainability, and increased automation, at least to the extent that automation will lower manning levels and reduce casualties related to operator error while maintaining sufficient personnel to counter battle damage. (Jolliff and Robertson, p18)

In 1975, the U.S. first employed marine gas turbines for propulsion aboard destroyers. Gas turbines required less mechanical support equipment than the steam plants. There was

a trade-off however, for electronic monitoring and support equipment that required fewer operating and maintenance personnel than the steam supporting equipment. Destroyer gas turbine engineering plants will normally have propulsion gas turbines, reduction gears, pumps, fuel oil purifying systems, gas turbine generators with auxiliary boilers in the main engineering spaces. Note that diesel generators are not included with equipment listing as the gas turbine generators are independent from the propulsion prime movers unlike the steam system. Counter to the automatic boiler combustion controls, the gas turbine electronic and hydraulic control systems are organic to the engine. No manual operation of current navy gas turbines can be performed.

Notable decreases in the engineering sizes of later destroyers can be directly attributed to the "moderate automation" of the power plant by machinery improvements. As of 1994, gas turbines have completely replaced steam plants in the destroyer navy.

D. SHIP CONTROL

Traditionally, the ship's bridge has been the location for commanding warships in battle.

> Safety of the ship (collision avoidance) and the crew (when many sailors routinely worked on exposed decks), and fighting the ship in a close-in surface action, are the requirements or "drivers" that have kept the conn on the bridge. (CNO, Ships Operational Characteristics Study, 1988, p18)

Since electricity was introduced to naval ships around the turn of the century, the navy has used some form of electrical system to "drive" ships. The 1960's, saw great advances in electronics which were applied to shipboard navigation.

> Electronics provided the means for great advances in navigation, as well. Shore based navigation systems such as Loran and Omega became more accurate and more automated. Earth orbiting satellites became beacons . . . As the period ended, satellite systems capable of defining a ship's position within a few yards, with little more effort than pushing a button, were a looming reality. (Barnes, Naval Engineering and American Seapower, 1989, p293)

Over the years, destroyer bridge teams have "driven" the ship with an average of ten personnel on watch. This total includes:

one officer of the deck, one conning officer, one quartermaster, one boatswain's mate, one helmsman, one lee helm, three lookouts, and one messenger. Navy bridge teams have used this composition for many years without regard to any advances in nautical technology. Any discussion of ship control automation and consolidation would be incomplete without acknowledging the major findings and contributions in this area made by the Integrated Bridge System (IBS) operational evaluation conducted aboard USS McCANDLESS (FF 1084) during the period November 1976 to January 1977. (CNO, 1988, p19)

> It was determined that a significant reduction in bridge manning could be achieved by consolidating and integrating communication and displays into a centralized work station and automating certain piloting, navigation, collision avoidance, and logging functions... The at-sea evaluation of the (IBS) design demonstrated that bridge watch functions can be performed as effectively or more effectively, with significantly fewer people. (Yurso, Naval Engineering and American Seapower, 1989, p354)

Unfortunately, IBS was not embraced during its operational evaluation by navy leadership. Commanders, at the

time, felt that the reduced bridge manning requirements would not lead to reduced crew sizes. This, in turn, would not lead to long term savings using capital-labor substitution.

> While acknowledging that "some reduction in bridge personnel during certain conditions of readiness is possible," (Commander Naval Surface Forces Atlantic Fleet) questioned whether "this reduction will result in reduced shipboard manning . . ." Another factor cited was the "cost involved, and the higher priority requirement for weapon and sensor development and acquisition." Certainly these factors were valid at the time, but times have changed and in a totally new time frame of the SOCS ship design real savings of people are possible and very real improvements in effectiveness can be realized." (CNO, 1988, p20)

E. COMMUNICATIONS

After the sinking of the TITANIC in 1912, the U.S. Congress passed a law that required all ships of a certain displacement be equipped with some type of wireless radio. (Fee, Naval Engineering and American Seapower, 1989, p79) By the 1920's, voice radio was beginning to show advances that would realize value aboard ship.

> With the advent of the wireless, radio telephone and radio telegraph went to sea. . . In 1940 . . . teletype went to sea. Other than on line encryption, the use of communication satellites, single-side ban, and one or two other innovations, there have been relatively few major changes in naval communications, especially in capacity and equipment commonality. As a matter of fact radio room configuration and equipment population have proven to be resistant to change. (CNO, 1988, p54)

The SOCS reviewed trends of communications operators, radioman (RM) rating. They observed work center manning and message traffic load capacity. The ship classes analyzed were the DDG 51 and the DD 931. The findings indicated a single

radioman working alone aboard DD 931 could handle 150 messages per day. The same radioman in DDG 51 could only handle 100 messages in a single day. Although the conditions are not really the same, message handling procedures have not improved dramatically. They certainly have not kept pace with the traffic volume increase. (CNO, 1988, p57)

One of the main problems with radio communication technology in the navy has been a lack of coordination in the development of various hardware components. Each type of transmission requires a different device to transmit and receive. Some equipment employed for like purposes on the same frequency may be noncompatible. Often, incremental improvements in equipment are performed which can result in awkward layouts of radio rooms that make processing message traffic arduous.

> Users demand dedicated circuits that they can control . . . The demand for dedicated circuits appears to have driven the configuration of today's communication suites. (ibid.)

Visual line of sight (LOS) communication has remained unchanged for many years in the navy, however SOCS recommended: "that the operational suitability, technological risk, and cost of suitable (LOS communications) be evaluated; and that one system be selected for R&D funding. The use of flag status signals can and should be retained independent of an improved LOS signaling system. (ibid, p63) This revolutionary change would involve the eventual removal of a navy occupation, signalman (SM) from destroyers and eventually the rest of the fleet. If this technical advance were to occur prior to 2003, then the topside ship design could be radically changed to improve stealth capability in addition to realizing manpower savings.

Internal communication developments have evolved following the Spanish-American War and voice tubes and "sound powered" phones replaced messengers as the primary means of station to station internal communication. As electricity was introduced, voice amplifying intercoms spread throughout the fleet. Even with the technical advancement, few believed that personnel reductions could occur through improving interior communications until the mid 1960's. Purdue University was funded through Advanced Research Projects Agency (ARPA) to evaluate the possibility of automating several processes aboard destroyer escorts in an effort to reduce manning requirements. The proposed automation involves the installation of four mini-computers, thirteen micro-processors, four "data highways," as well as sensors, actuators, and associated displays. However to get the savings, what is important is not the number of individuals saved by the automation, but the kinds of personnel saved. (Shishko, 1975, pp14-15) The study demonstrated that improvements in interior communications could yield personnel reductions and savings over the long term if implemented during the initial construction of an entire ship class. The costs of back fitting such a system aboard already active ships out weighed the savings in personnel trade-offs throughout the expected lifetime of the ships. Interestingly, the proposal only covered the destroyer escorts and was not considered for any destroyers. It was not implemented in the fleet. The commercial shipping industry has taken advantage of a variant of this system.

In 1994, the Naval Sea Systems Command (NAVSEA) began development of the Integrated Interior Communications and control System $(IC)^2$. This system is designed to:

•collect and distribute incoming and outgoing traffic

- connect all shipboard components, systems, and departments
- pass all data, information, voice, video, and orders between on board users.

$(IC)^2$ provides information to the Commanding Officer (CO) to assist in exercising command and control within the ship. It aids in his decision making process and enables the passing of orders by supplying fused and high level information rather than simply raw data. Ultimately development and implementation of $(IC)^2$ will provide the CO and Executive Officer (XO) with real-time status information from multiple sources. Potential systems to be interfaced in a "user friendly" manner are:

- Combat systems
- Navigation
- Damage control
- Propulsion and electrical plant
- Administration
- Others

This interfacing is to occur using personal computer (PC) based technology with fiber optic local area networks (LAN). Current goals are to apply the finalized $(IC)^2$ system to ships beginning in fiscal year 1995. (Wood, 1994) No evaluations have been made to estimate possible manpower reductions yet.

TREND DATA OF U.S. NAVY DESTROYERS 1934 - 1991

SHIP CLASS	COST IN MILLIONS OF CONSTANT FY93 DOLLARS [1]	DISPLACEMENT IN TONS (FULL LOAD)	MANNING	WEAPONS	MISSION
DD 348 1934-38	54	1500	167	5 GUNS TORPEDOES	ASUW
DD 445 1942-43	101	2750	250-300 peace 350 war	5 GUNS TORPEDOES rcvd FRAM	ASUW after FRAM ASW
DD 692 1943-44	69 (less armament)	3000	350 war	6 GUNS 12 AAW GUNS rcvd FRAM	ASUW after FRAM ASW
DD 710 1944-46	67 (less armament)	3300	257 peace 350 war	6 GUNS 12 AAW GUNS rcvd FRAM	ASUW after FRAM ASW
DL 2 1953-54	150	4400	350 peace 440 war	2 GUNS 4 AAW GUNS WEAPON ALFA	ASUW & ASW
DD 931 1955-58		4200	337	3 GUNS 4 AAW GUNS 2 HEDGE HOGS TORPEDOES	ASUW & ASW
				ASW version (ASROC)	ASW & ASUW
				AAW version (TARTAR MISSILES)	ASUW & AAW

Table 2-1 Destroyer Characteristic Trends

SHIP CLASS	COST IN MILLIONS OF CONSTANT FY93 DOLLARS	DISPLACEMENT IN TONS (FULL LOAD)	MANNING	WEAPONS	MISSION
DDG 37 1960-61	220	5800	431	1 GUN ASROC STANDARD MISSILES TORPEDOES HARPOON	AAW, ASUW, & ASW
DDG 2 1960-64	147	4500	385	2 GUNS ASROC STANDARD MISSILES TORPEDOES HARPOON	AAW, ASUW, & ASW
DD 963 1975-83	229	8040	373	2 GUNS ASROC LAMPS TASM/TLAM CIWS, BPDMS HARPOON TORPEDOES	ASW & ASUW
DDG 993 1981-82	682	9574	349	2 GUNS ASROC STANDARD MISSILES LAMPS TORPEDOES HARPOON CIWS	AAW, ASW, & ASUW

Table 2-1 (Continued).

SHIP CLASS	COST IN MILLIONS OF CONSTANT FY93 DOLLARS	DISPLACEMENT IN TONS (FULL LOAD)	MANNING	WEAPONS	MISSION
DDG-51 1992-98	869	8422	338	1 GUN STANDARD MISSILES TASM / TLAM ASROC TORPEDOES HARPOON CIWS	AAW, ASUW. & ASW

Note 1. Costs in constant 1993 dollars are derived from the summary estimates of fixed reproducable tangible wealth in the United States. (Survey of Current Business, Department of Commerce, August 1994).

Table 2-1 (Continued).

III. HISTORICAL MANNING AND COST COMPARISON OF U.S. NAVY DESTROYERS

This chapter summarizes recent destroyer class manning trends. This summary could be helpful for estimating the manpower requirements of future destroyers. Chapter IV will discuss possible advances in various systems and the manpower requirements associated with one proposal. Chapter V will project the manning and cost requirements of the future prototype.

A. REQUIREMENTS

This chapter provides raw manning and manpower cost requirements for seven destroyers commissioned from 1960 and 1991. All costs will be listed in constant 1993 (FY93) dollars. The sample includes 5 destroyer classes. Each ship in this sample has a unique configuration representing a broad spectrum of the classes listed. This sample contains the following ships: USS MAHAN (DDG 42), USS LYNDE MCCORMICK (DDG 8), USS BENJAMIN STODDERT (DDG 22), USS MERRILL (DD 976), USS CUSHING (DD 985), USS KIDD (DDG 993), and USS ARLIEGH BURKE (DDG 51). The ship classes and a brief description are listed in Table 3-1.

CLASS	SHIP	COMMISSIONED	PROPULSION PLANT	MAJOR MISSILE SYSTEM
DDG 37	USS MAHAN (DDG 42)	1960	STEAM	MK 10 TERRIER
DDG 2	USS LYNDE MCCORMICK (DDG 8)	1961	STEAM	MK 11 TARTAR
DDG 2	USS BENJAMIN STODDERT (DDG 22)	1964	STEAM	MK 13 TARTAR
DD 963	USS MERRILL (DD 976)	1978	GAS TURBINE	TOMAHAWK (ABL)
DD 963	USS CUSHING (DD 985)	1979	GAS TURBINE	TOMAHAWK (VLS)
DDG 993	USS KIDD (DDG 993)	1981	GAS TURBINE	MK 26 STANDARD
DDG 51	USS ARLIEIGH BURKE (DDG 51)	1991	GAS TURBINE	AEGIS (VLS) STANDARD & TOMAHAWK

Table 3-1 Brief Descriptions of Sample Ship Characteristics.

> ...The Navy uses the ship workload (the operational and maintenance tasks which assigned ship personnel would have to perform in wartime) and staffing standards (the amount of time and skills needed to perform these tasks that identify the number of positions needed to accomplish a given amount of work. The resulting output is a determination of the number and types of positions needed to operate a given ship during wartime. (GAO, 1986, pp 11-12)

Navy Manpower Analysis Center (NAVMAC) is assigned to develop and document total wartime manpower requirements for all fleet activities of the Navy. (CNO, 1990, pC-2) Naval Sea Systems Command (NAVSEASYCOM) performs manpower personnel and training analysis for ships systems and

equipment designed for installations in Navy shore and ship activities. (Ibid, pC-3) NAVSEASYSCOM calculates the initial manpower requirements in the design and construction phase of the prototype ship of a given class. After the initial ship has been commissioned tested, and evaluated; the ship and NAVMAC assess the utility of the preliminary manpower allotments. They then report the findings and recommendations up the chain of command to the Deputy Chief of Naval Operations (DCNO) for manpower, personnel, and training. The SMD for the class is then finalized and future ships of the class are manned according to the finalized SMD. Similar processes occur if any follow-on ships of the class receive different equipment or alterations.

Ship manpower requirements are determined with respect to five key elements: watch stations (ws), own unit support (ous), preventive maintenance (pm), corrective maintenance (cm), and facilities maintenance (fm). The elements are defined as:

- ws -- essential positions to properly operate ship systems, subsystems and equipment (i.e., deck, engineering, weapons, and communications)
- ous -- administration, supply, food service, medical, utility, and special evolutions
- pm -- scheduled periodic "preventive" maintenance
- cm -- repair of damaged or deteriorating equipment
- fm -- cleaning and preserving all regions of the ship against corrosion and deterioration.

The work load and the staffing standards for each of these areas varies according the condition of readiness the ship is to maintain. The

> conditions of readiness are condition I - battle readiness, condition II - battle readiness with limited action, condition III - wartime cruising readiness, condition IV - peacetime cruising readiness, and condition V - in-port readiness. Full manning at condition III (wartime cruising) is generally the most demanding because it calls for three shifts in order to staff each watch station needed to meet mission requirements 24 hours a day. Thus, at condition III, each watch station equates to three people. (GAO p13)

B. SHIP MANNING TRENDS

The destroyer manning trends in the Navy are subtle but noticeable over a thirty year period, shown in Figures 3-1 and 3-2. In 1959 and 1960, the first guided missile destroyer class was commissioned (DDG 37 ex DLG 6.). These ships were designed as multi-faceted platforms with AAW, ASW, and ASUW capability wrapped into one ship. The ships had 431 men and officers assigned. The DDG 2 class was built from 1959 to 1964 with a smaller hull design than the DDG-37 and had several differences in armament. The class was composed of two flights essentially. DDG 2-14 possessed the MK 11 missile launching system. DDG 15-24 employed the MK 13 missile launchers. The crew complement for DDG 2-14 was 379 officers and men. The later series required 391 officers and men. The DD 963 classes proliferated throughout the fleet from 1975 to 1983. This class was significantly different from previous destroyers in design and engineering. This was the first class of U.S. destroyer to employ marine gas turbine engines vice steam for main propulsion and power. The DD 963 class received over the horizon (OTH) "strike" capability with the addition of the TOMAHAWK land attack missile (TLAM) and the TOMAHAWK anti-ship missile (TASM), a first for destroyers. DD 963 class ships were also the first U.S. Navy destroyers designed to

house and operate light air-borne multipurpose system (LAMPS). The DD's are now configured in two separate manners. Seven of the SPRUANCE class launch Tomahawk missiles from armored box launchers (ABL) and twenty-four of the class possess the MK 41 vertical launching system (VLS) to launch either Tomahawk or ASROC. The manning for the ABL configured ships consists of 367 enlisted and officer personnel. The VLS ships require 373 officers and enlisted crew. The DDG 993 class is configured similar to the DD 963 except that it is geared for anti-air warfare (AAW) vice the "strike" role. Crew complement for this class is 349 combined enlisted and officer personnel. In 1992 the first DDG 51 class ship was commissioned. The DDG 51 has more fire-power, more displacement, and more steel than any other destroyer in the U.S. fleet. Like the earlier DDG's, this class carries no helicopter, though it possesses a landing area. DDG 51 employs the AEGIS air defense system and is also TLAM/TASM capable. This class has the smallest complement of the five classes listed with 338 officers and enlisted personnel.

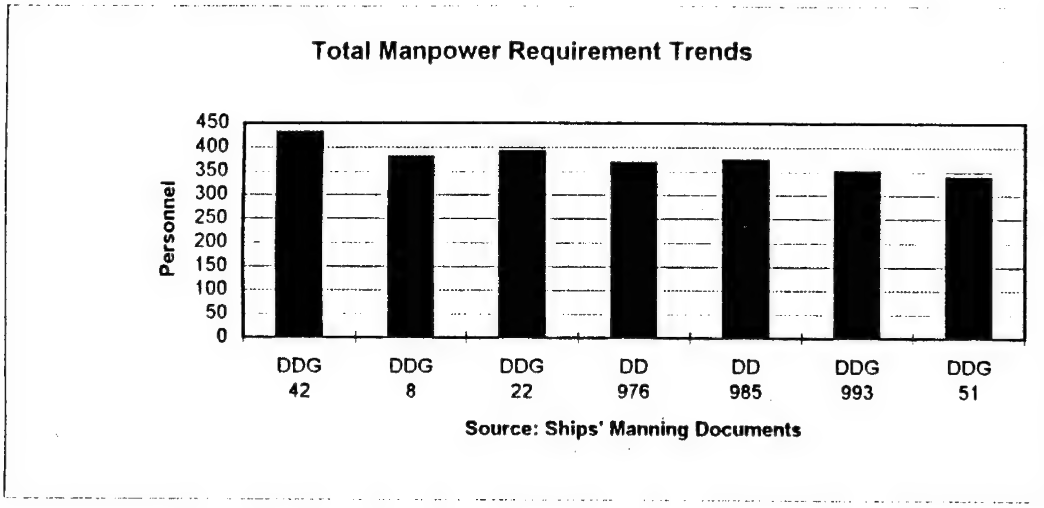

Figure 3-1 Total Destroyer Manpower Requirement Trends.

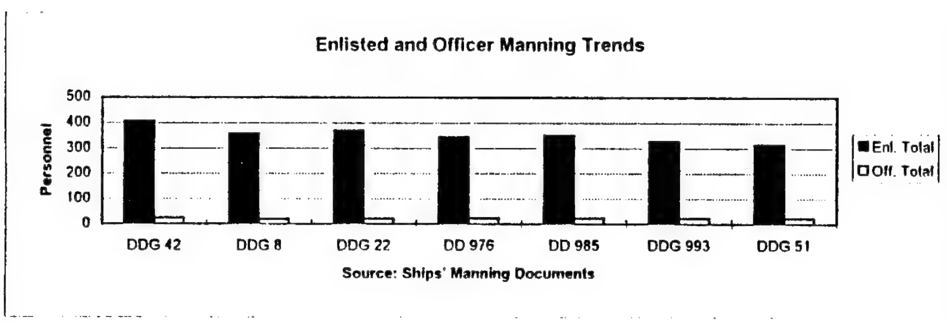

Figure 3-2 Enlisted and Officer Manning Trends.

C. DEPARTMENTAL ORGANIZATION

To better understand the depth and breadth of the manpower requirement trends, one must understand the personnel organization aboard destroyers. The primary

function of ships of the United States Navy is either to fight or support combat operations. If a ship is to function well in combat, the crew must be organized in a way that it can be effectively directed and controlled. The five basic departments found on all U.S. Navy ships are Navigation, Operations, Weapons or Combat Systems, Engineering, and Supply. The ship's organization may include other departments to fulfill the its assigned tasks. (Naval Institute, pp 2,3) This study will analyze the ships by the following departments: Executive, Navigation, Medical, Operations, Combat Systems/Weapons, Engineering, and Supply (Figure 3-3). The officers of a ship include the Commanding Officer (CO), Executive Officer (XO), Department Heads, and Division Officers. They are organized in a hierarchical fashion. Most of the officers are unrestricted line officers. This means that they are potentially eligible for command-at-sea. Officer occupations are identified by designator. The unrestricted line officers aboard destroyers are designated either 1110 if surface warfare qualified or 1160 if not surface warfare qualified. The remaining officers are either restricted line (not eligible for command-at-sea)(designator 1610), limited duty (designator 6000 series) or warrant officers (designator 7000 series.) The Medical and Supply officers are staff corps officers. Staff corps officers are specialized officers who are not eligible for command-at-sea. Medical officers are designated 2100 and Supply officers are designated 3100. Departmental organizational diagrams are listed in Figures 3-4, 3-5, 3-6, and 3-7. The other (non-department head) officers are responsible for heading the divisions. Divisions are usually composed of enlisted

personnel with similar occupations (ratings). The enlisted ratings traditionally have been grouped according to specialized tasks that they perform. The personnel operate and maintain certain equipment or perform specific tasks to fulfill a discreet aspect of the ship's mission. Enlisted occupations, or ratings are described in The Navy Enlisted Retention Manual. The specific divisions are then subdivided into maintenance "work centers."

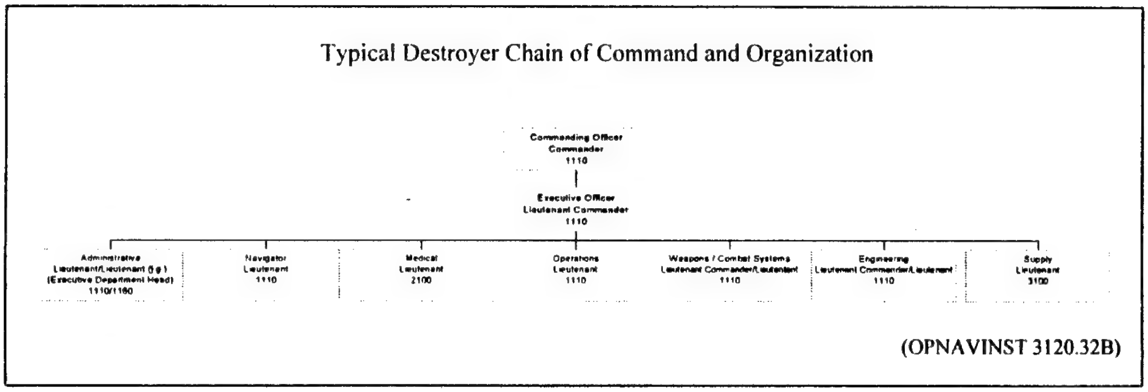

Figure 3-3 A Typical Destroyer Chain of Command.

1. Departmental Description

For the purpose of this study, the departments are defined by mission and responsibilities.

Executive Department: responsible for the various administrative functions aboard a U.S. Navy Ship. The department is normally composed of personnelmen (PN), yeomen (YN), master-at-arms (MA), navy counselor (NC), postal clerk (PC), a 3-M (maintenance, material, management) Coordinator

(can be almost any rating), the Command Master Chief (any rating.) A line officer usually acts as the department head aboard destroyers.

Navigation Department: responsible for the safe navigation and ceremonial events of the ship. The department consists of quartermasters (QM) and is headed by a line officer. In the Atlantic fleet, the Executive Officer is designated as the Navigator aboard destroyer size vessels.

Medical Department: acts as the health care provider aboard destroyers. The department is composed of hospital corpsmen (HM) and headed by a Medical Staff Officer (in wartime only).

Operations Department: responsible for the collection, evaluation, and dissemination of combat and operational information required for assigned missions (Figure 3-4). The department is also responsible for deck seamanship responsibilities if there is not a weapons department. The department is staffed by operations specialists (OS), radiomen (RM), signalmen (SM), electronic warfare technicians (EW) [on most destroyers], electronic technicians (ET) and data systems technicians (DS)[if the ship has a weapons department], boatswain's mates (BM) [if the ship does not have a weapons department], seamen (SN), cryptologic technicians (CT varieties) [aboard DD 963 class only], and intelligence specialists (IS) [DD 963 class only]. The department is headed by a line officer and consists of several divisions. The division officers may either be line, limited duty, warrant, or restricted line officers.

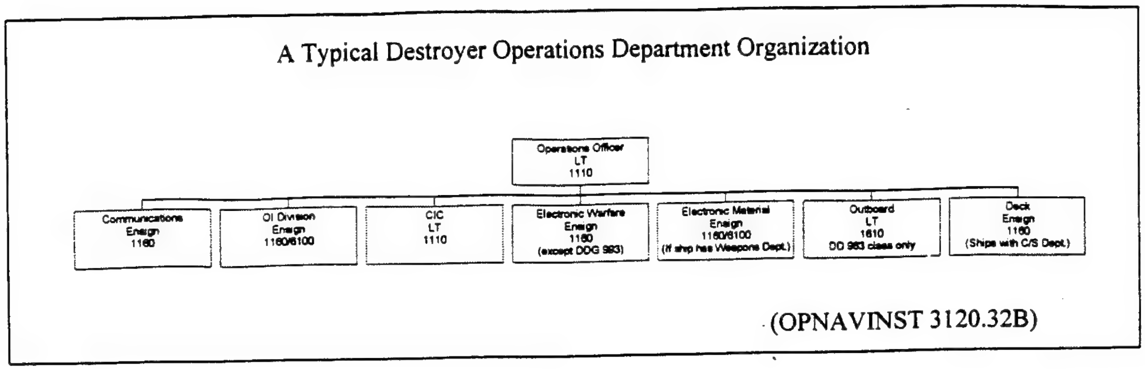

Figure 3-4 Typical Destroyer Operations Department.

Combat Systems Department: responsible for the direction of employing the units combat systems including ordinance. Weapons Department would be responsible for employing the unit's weapon systems including ordinance and deck seamanship (Figure 3-5). The Combat Systems Department is composed of gunner's mates (guns and missiles)(GMG, GMM), fire controlmen (FC), electronic technicians (ET) and data systems technicians (DS)[not in Weapons Department], Sonar technicians (STG), torpedomen (TM), boatswain's mates (BM) [in weapons department], and seamen (SN). The Combat Systems/Weapons Department head is a line officer and division officers are either line, limited duty, or warrant officers.

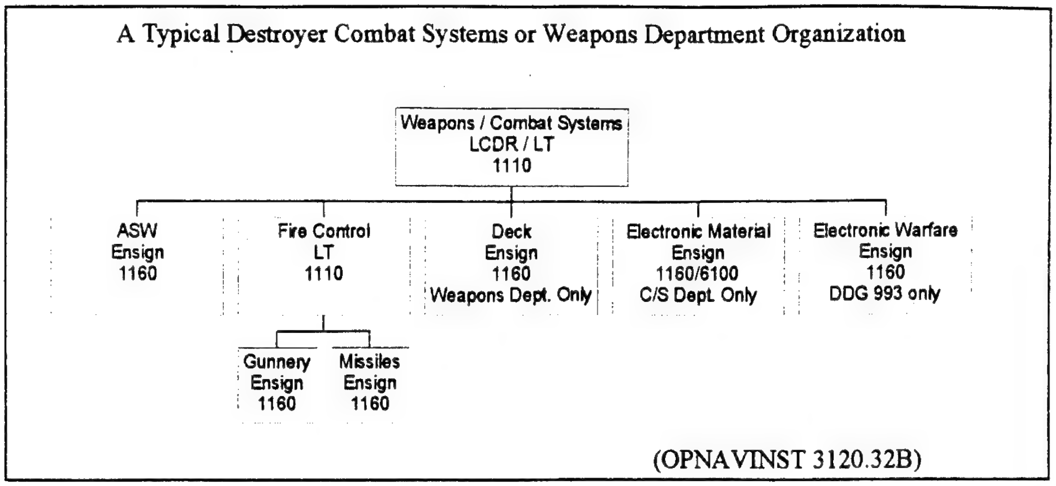

Figure 3-5 A Typical Destroyer Combat Systems or Weapons Department.

<u>Engineering Department</u>: responsible for propelling ship, allowing maneuverability, providing electrical power, air conditioning, damage control, stability, repairing and other mechanical and electrical services (Figure 3-6). The department is composed of the following occupations: boiler technicians (BT)[steam ships only], machinist mates (MM)[steam ships only], gas turbine technicians (mechanical and electrical) (GSM/GSE), enginemen (EN), electrician's mates (EM), interior communication electricians (IC), machinery repairmen (MR), damage controlmen (DC), and hull maintenance technicians (HT), and firemen (FN). The department head is a line officer and is supported by either line, limited duty, or warrant officers.

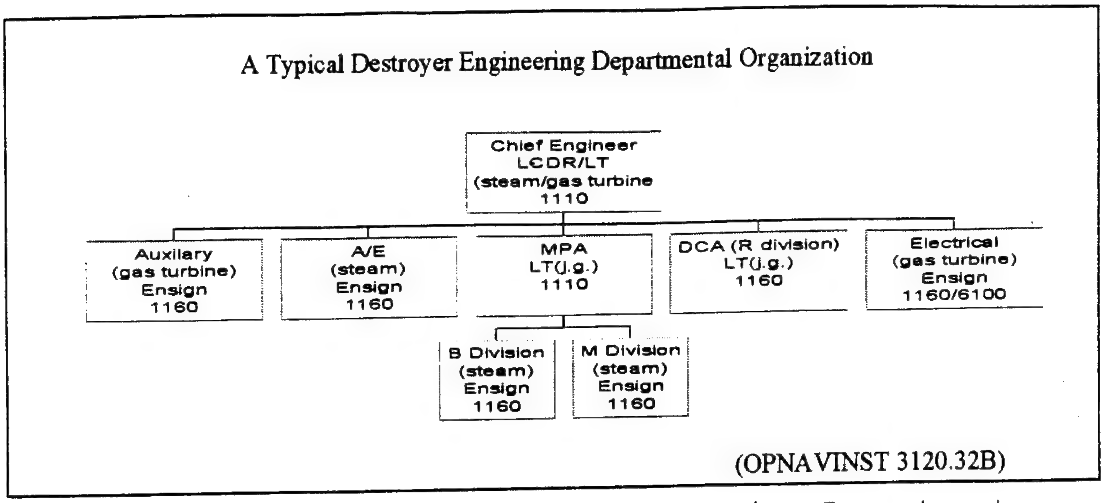

Figure 3-6 A Typical Destroyer Engineering Department.

Supply Department: responsible for logistical replenishment and management of parts, food, and money (Figure 3-7). The department also provides retail services such as snack foods, hair cutting, and laundry. The department is also responsible for preparing meals for the crew. The department is staffed with the following personnel: storekeeper (SK), mess management specialists (MS), ship's servicemen (SH), disbursing clerks (DK), seamen (SN), and firemen (FN). The department is headed by a supply staff corps officer and assisted by one junior supply staff officer. (OPNAVINST 3120.32B)

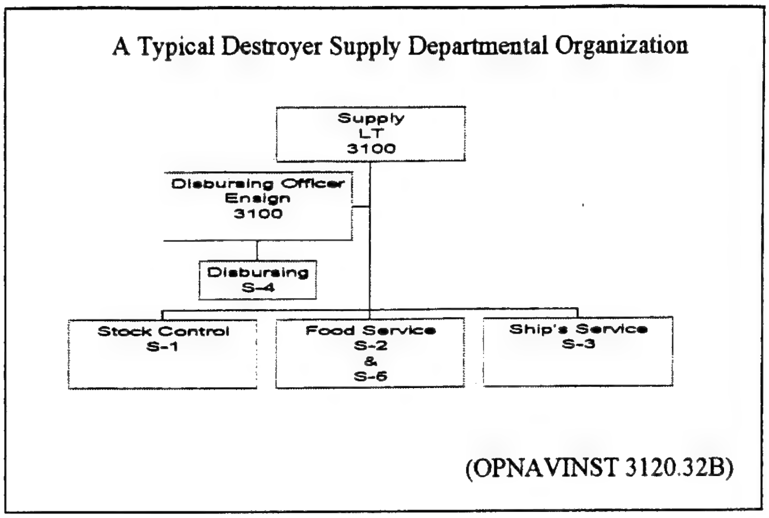

Figure 3-7 A Typical Destroyer Supply Department.

2. Discussion

In recent years the navy has come under scrutiny from several management analysts as having an outmoded and inefficient managerial (organizational) structure. The ships' organizational structure appears outdated when compared to the evolution that has occurred in private industry. (Lovelace, p15) Unfortunately, destroyers cannot be instantly compared to merchant ships of similar displacement. Their missions are drastically different. The crew size and composition are similar only in deck watch standing, engineering watch standing, cargo handling, and food preparation. Merchant ships, as a rule, do not fire weapons, search for airplanes or submarines, launch helicopters, or send and receive radio and visual messages around the clock. The navy employs young unlicensed men and

women to sail and operate these warships. Civilians hire mostly experienced and licensed mariners to move cargo from point to point. The relatively high personnel numbers can be partially attributed to hiring young persons (18 to 22 years old) and training them aboard ship. If destroyers were composed of only fully trained and experienced personnel, then some manpower requirements would drop significantly. Another organizational constraint is the requirement for a career counselor and numerous clerical workers. Personal computers have made clerical workers less valuable than before. Black box technology has become the normal technical advancement aboard modern ships since the development of the DD 963 class and later ships. As electronic components replace mechanical components, the trends will show smaller personnel requirements in affected occupations. The final real constraint that keeps personnel numbers high aboard destroyers is the Navy ROC/POE statement. If the ROC/POE listed 30 to 45 days continuously underway in wartime steaming vice 60 days, then crew size could theoretically be reduced. Unfortunately, the resulting crew reduction would also yield reduction in combat effectiveness. The author does not see reducing combat effectiveness as an advantageous solution to rising personnel costs.

Currently information technology may be waiting to change to change the destroyer workplace to yield reductions in personnel. Unfortunately, the destroyer would have to be built with the substitution in mind prior to development. The navy has benefited from initial planning developments in the case of the DD 963 class destroyers in comparison to the elder DDG 37 and DDG 2 class ships. Computers were an

important aspect in developing the DD 963 and DDG 993 ships. The classes feature NTDS, SNAP II (a logistical computer system), SQQ 89 (in some ships) [a digital data link for ASW which coordinates, the ship's sonar, TACTAS, and the helicopter's information to compile a unified underwater "picture"], and a "somewhat" automated engineering plant. Computers also play an important role in the development of the DDG 51 class with a bit more sophistication than earlier classes. The AEGIS tactical defense system combined with NTDS and local area network (LAN) technology were the highest profile computer advances that have been employed. These advances vastly improved tactical and non-tactical information management. Unfortunately, the BURKE's were designed and configured immediately prior to the vast productivity improvements in industry. The next logical step in this evolution to design a ship that better exploits the capabilities of computers vice using computers to replicate human effort. This topic will be expanded in chapter four. With this background, we can now observe the manning trends over the past thirty years of destroyer development and make generalizations.

D. DEPARTMENTAL MANNING TRENDS

1. Executive Department

The Executive Department manning trends show slight fluctuations in requirements over the classes from fourteen persons to eleven (Figure 3-8). This variation can be explained by DDG 22 having two uncommon requirements unique in this sample of destroyers. None of the other ships have a requirement for either an IC or a JO. Ships in the sample commissioned after 1978 (except DDG 51) each have a compliment of six YN's. The others have a requirement of

five YN's. DDG 42, DD 976, and DD 985 have all YN requirements grouped in the Executive Department because the respective SMD's listed and grouped requirements by rating rather than department and division. The author grouped the YN requirements in the Executive Department for accounting convenience. DDG 8, 22, 993, & 51 have three YN requirements in the department. The other YN requirements are dispersed to either two or three of the operational departments (Operations, Weapons/Combat Systems, or Engineering.) If all of YN requirements are similar and DDG 22 has no unusual configuration, then all of the ships in the sample who have eleven personnel in the department. Unless the standards for ous are higher for the ships commissioned on the SPRUANCE hull (DD 976, DD 985, DDG 993), there is no current explanation for the additional YN aboard these platforms. DDG 8 and DDG 22 do not have a YN requirement in the Operations Department. DDG 51 does not have a YN requirement in the Combat Systems Department. These ships have one MA, one NC, one PC, two PO's (E-8 and E-9 of any rating), three PN's. The main impetus for Executive Department manning is ous.

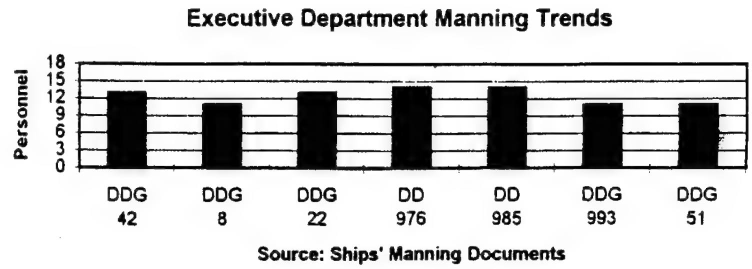

Figure 3-8 Executive Department Manning Trends.

2. Navigation Department

The Navigation department manning trends do not vary throughout the sample (Figure 3-9). Each ship has a requirement for one E-6, one E-5, two E-4, and one E-3 in the QM rating. Theoretically, the most significant factors determining QM manning are ws and ous.

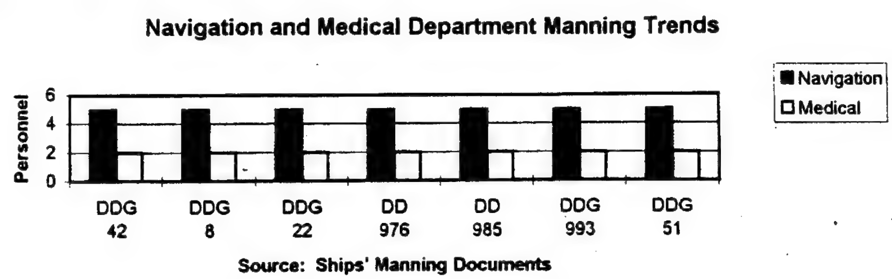

Figure 3-9 Navigation and Medical Department Manning Trends

3. Medical Department

The Medical department manning trend, like the Navigation Department, show no variance throughout the sample (Figure 3-9). Each ship requires two HM's, one E-7 and one E-4. Ous is the key determinant for manning this department.

4. Operations Department

The Operations Department manning trends vary throughout the sample (Figure 3-10). Most of the variance can be attributed to a departmental reorganization that shifted Electronics "away from" and Deck Division "to" the Operations Department aboard those ships who transitioned the Weapons Department to a Combat Systems Department (DD 976 and later ships.) DD 976 and DD 985 have an additionally larger department because they are configured with OUTBOARD and 17 personnel (16 CT and 1 IS) in support. A "1610" designated restricted line officer (cryptology) serves as the OUTBOARD Division Officer. Also, DDG 993 has its Electronic Warfare Division in the Combat Systems Department. The Departmental trends can be explained by analyzing the individual ratings. The ratings grouped together form the divisions, which as whole comprise the department. RM's differ from platform to platform and currently show an increasing trend. OS numbers differ across platforms as well however they currently are showing a downward trend. The ships show no variance in SM CT, and IS ratings. The number of BM's and SN should in theory depend on the area of topside space per platform. Ws is the primary driver for the Operations Department manpower requirements other than Deck Division. Fm requirements dictate BM and SN manpower requirements.

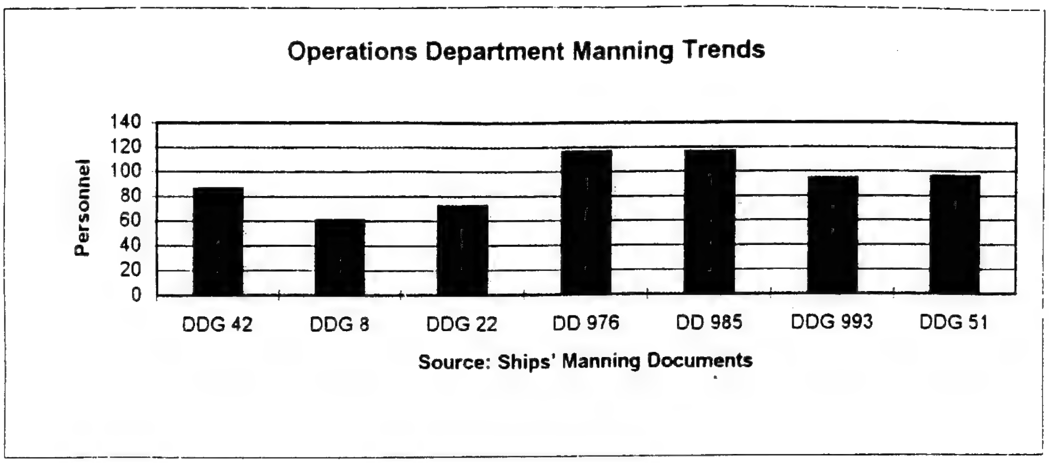

Figure 3-10 Operations Department Manning Trends.

5. Weapons/Combat Systems Department

The trends across the samples show numerical decreases in some ratings and increases in others (Figure 3-11). Another big shift is in the type of rating. The manual "unskilled" labor has been shifted over to the Operations Department (BM and SN ratings) in the later ships (with a Combat Systems Department). Deck Division was replaced with two varieties of Electronic Technician ratings (ET and DS). DDG 51 has no DS requirement because the ET and FC ratings have acquired the background training on systems to take over maintenance, which yielded a net reduction in overall personnel requirements. The Gunnery Divisions (GMG and FC) have seen personnel decreases as guns have become fully automated. This also greatly reduced the need for additional ammunition handlers (which came from Deck Division). The Missile Division (GMM and FC) trends have decreased somewhat over the years until DDG 51. The ASW Division (GMM, STG, TM) personnel numbers have reduced over

the years. This is largely a result of removal of a GMM requirement, as a result of alternative ASROC launch configurations in DD 985, DDG 993, and DDG 51 compared to the "pepper box" ASROC launchers on the other ships. Weapons Department manning requirements are driven mainly by fm, pm, and cm. Combat Systems Department manning is determined more by pm, cm, and ws.

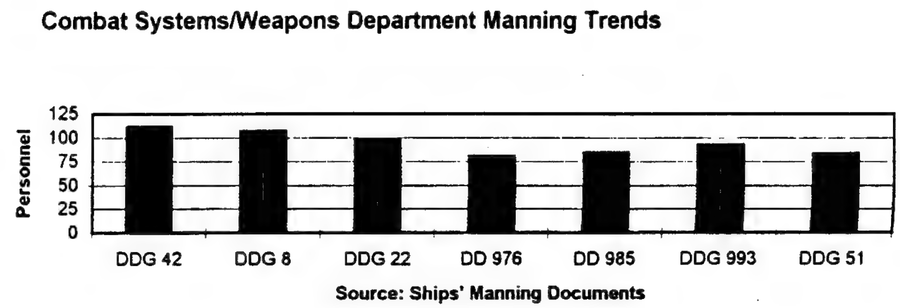

Figure 3-11 Combat Systems/Weapons Department Manning Trends.

6. Engineering Department

The most significant personnel reductions aboard destroyers have been realized in the Engineering Department as a result of transitions from steam to gas turbine propulsion (Figure 3-12). The main propulsion divisions have seen drastic reductions in the number of personnel and the elimination of one division (B Division [BT & FN] and M Divisions [MM & FN] into MP Division [GSE, GSM, & FN]). At

the same time, Auxiliary Division branched into two separate divisions A/E Division (EM, IC, EN, MM, MR, & FN) to A Division (EN, MR, & FN) and E Division.(EM & IC). Repair Division (DC, HT, & FN) has seen fairly consistent numbers. The department as a whole has been cut in half as a result of employing gas turbine and other solid state technology.

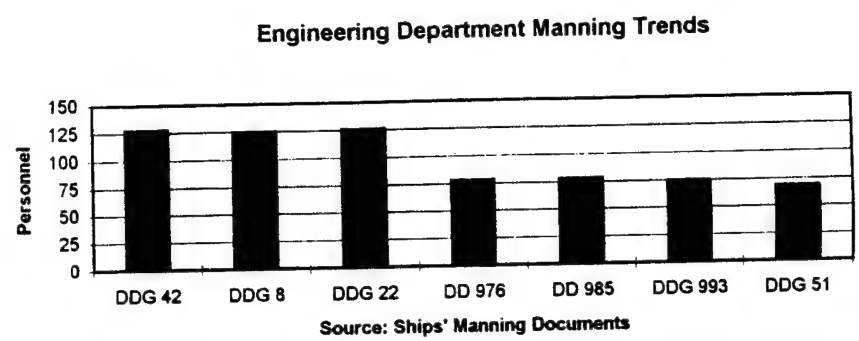

Figure 3-12 Engineering Department Manning Trends.

7. Supply Department

The Supply Department has also seen reductions in manpower requirements over the years (Figure 3-13). The largest reductions in personnel have come from the S-2 Division (food service) (MS, SN, & FN). The S-3 Division (ship's service) (SH & SN) has seen slight increases over time. The S-1 (Stock Control) (SK & SN) and S-4 (Disbursing) (DK) Divisions have shown steady trends.

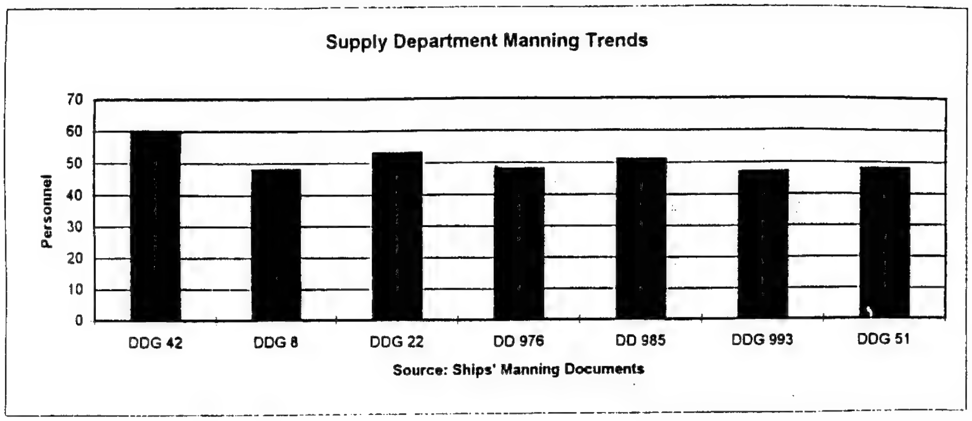

Figure 3-13 Supply Department Manning Trends.

E. DISCREET RATING TRENDS AMONG THE FOUR MAJOR DEPARTMENTS (OPERATIONS, WEAPONS/COMBAT SYSTEMS, ENGINEERING, SUPPLY)

1. Boatswain's Mate (BM) (Weapons, Operations)

Actual BM requirements have shown a downward trend aboard destroyers (Figure 3-14). Without the actual manpower requirement calculations, one must assume that improvements in topside preservation equipment, automation of gun mounts, and small boat improvements have played a significant factor in allowing the reduction of 16 BM personnel requirements aboard DDG 42 to 11 aboard DDG 993 & 51. Fm and ws are theoretically biggest factors driving BM manning requirements.

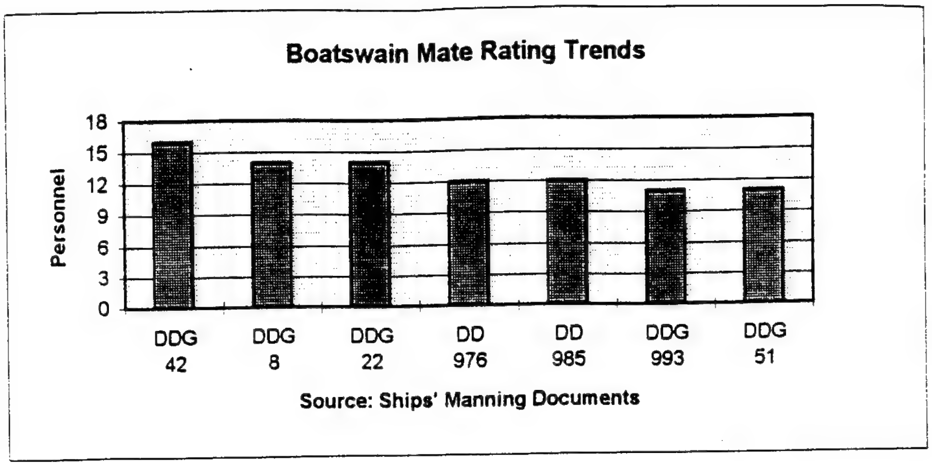

Figure 3-14 Boatswain Mate Rating Trends.

2. Boiler Technician (BT) (Engineering)

BT requirements show a decreasing trend in the steam ships (Figure 3-15). There are no requirements for BT's aboard the gas turbine ships. This fact has helped decrease the Engineering Department manning. Ws and pm probably dictate the largest requirements for BT personnel.

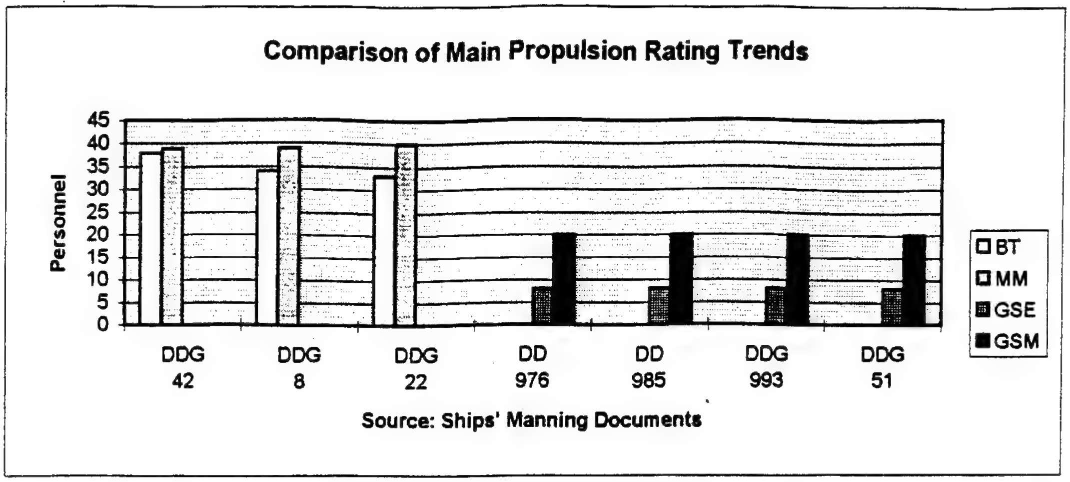

Figure 3-15 Main Propulsion Rating Trends.

3. Damage Controlman (DC) (Engineering)

DC manpower trends appear related to the displacement of the respective ship (Figure 3-16). The one exception to this observation is DDG 22 that has no DC requirements listed on its SMD (HT's fill the requirements). DDG 42 & 8 have eight DC requirements while DD 976, 985, & DDG 993 have ten requirements. DDG 51 has a requirement for nine DC personnel. Pm and cm probably push these requirements.

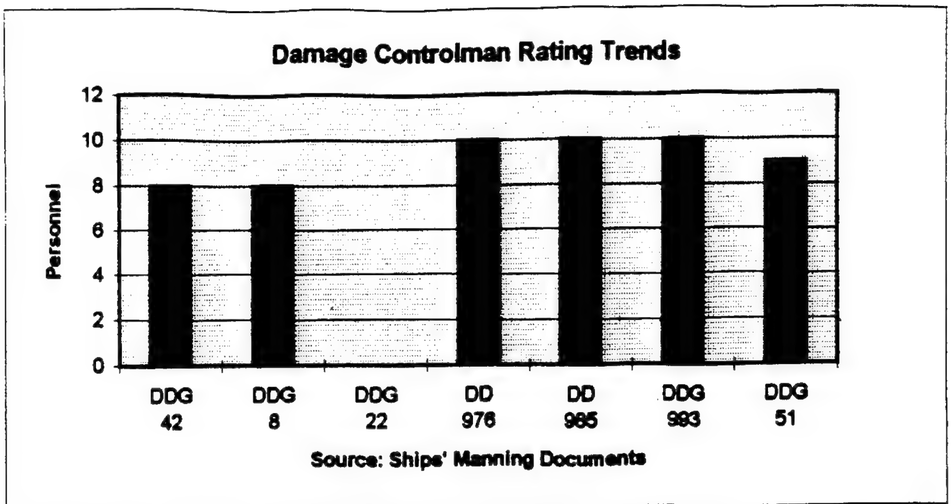

Figure 3-16 Damage Controlman Rating Trends.

4. Data Systems Technician (DS) (Operations, Combat Systems)

The DS rating was initially established aboard DDG 42 to maintain the NTDS (Figure 3-17). DDG 42 has eight DS requirements. DDG 8 was configured without NTDS and there fore has no DS requirements. DDG 22 received NTDS later in life and has five DS requirements. DD 976 & 985 each have seven DS requirements while DDG 993 has eight personnel requirements. DDG 51 has no DS requirements because the FC rating has absorbed the AEGIS and NTDS computer maintenance requirements and the ET rating performs maintenance on the non tactical computer systems. In the future, this rating will probably merge with those two ratings. Pm and cm probably play the largest role in determining DS manning.

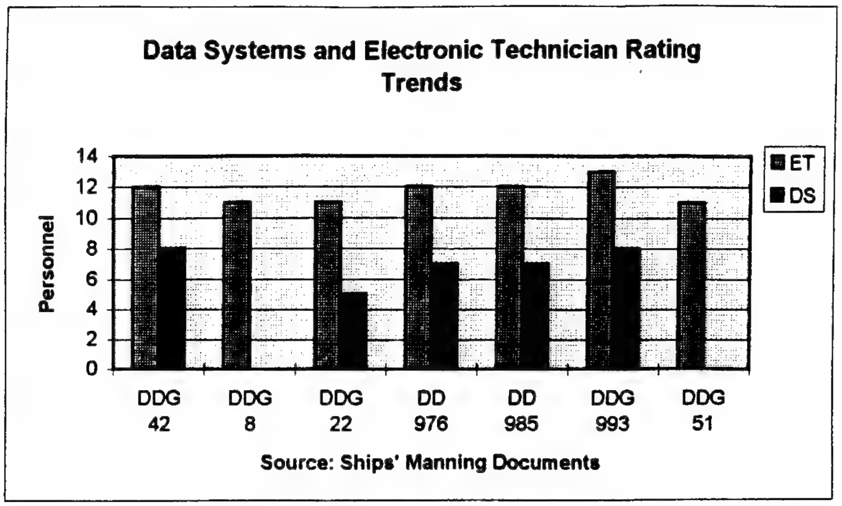

Figure 3-17 Data Systems and Electronic Technician Rating Trends.

5. Electrician's Mate (EM) (Engineering)

EM's have seen decreasing requirements through the years (Figure 3-18). The steam ships (DDG 42, 8, & 22) required eleven EM personnel each. The requirements aboard DD 976 & 985 are six EM's, while DDG 993 & 51 require only five personnel. In the gas turbine ships, EM's have been substituted with GSE's to maintain and repair electrical systems in the main propulsion and auxiliary engineering spaces, which accounts for the reduced EM requirements. Aboard the steam ships ws, pm, and cm drove manning requirements, while the gas turbine manning is pushed only by pm and cm.

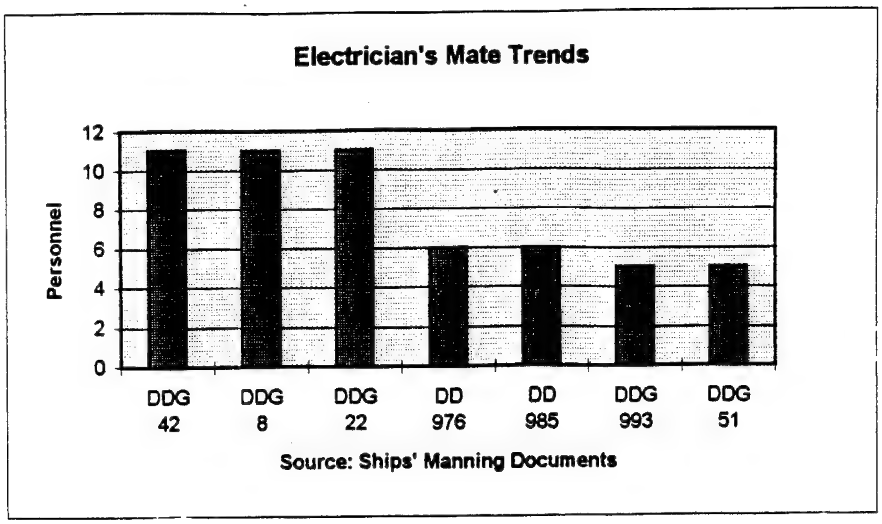

Figure 3-18 Electrician's Mate Rating Trends.

6. Engineman (EN) (Engineering)

EN requirements have increased dramatically through the years, but is now showing declining requirements (Figure 3-19). This occurred as a result of removing the MM rating from gas turbine ships. The steam ships rate two EN personnel. Aboard those ships, the EN's only performed maintenance on the emergency diesel generator engines and the ships' small boats. Aboard the DD's, the EN responsibilities expanded to all non-electric components of auxiliary equipment. EN's also have the responsibility of maintaining the aviation fuel system for the helicopters. This expanded the EN requirements to thirteen. DDG 993 was the first destroyer to employ low maintenance rigid hull inflatable boats (RHIB) in place of the old fashioned labor intensive traditional "motor whale boats." DDG 993 has twelve EN requirements. DDG 51 has only seven requirements that could be related to no helo service capability. Pm and cm probably dictate requirements for EN manning.

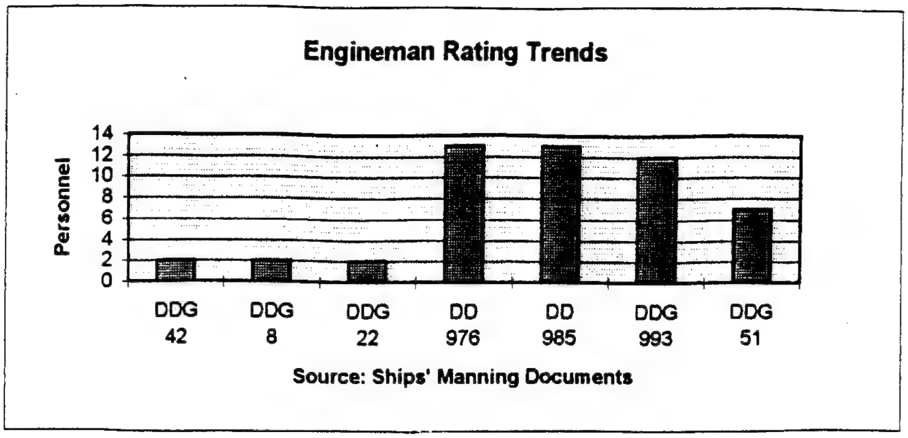

Figure 3-19 Engineman Rating Trends.

7. Electronic Technician (ET) (Operations, Combat Systems)

ET manning requirements display an interesting cyclic trend (Figure 3-17). DDG 42, DD 976 & 985 each have twelve ET requirements while DDG 993 has thirteen requirements. DDG 8, 22, & 51 have eleven requirements. The difference in requirements may be a result of the total number of radars and radio equipment to maintain and repair. Pm and cm are major determinants of ET manning.

8. Electronic Warfare Technician (EW) (Operations, Combat Systems)

EW's have hovered between six and seven requirements for all seven ships (Figure 3-20). Though all seven ships received SLQ-32(V2), the DD 976, 985, DDG 51 may have received the "side-kick" modification that has a "jamming" feature. These ships have seven EW requirements while DDG 42, 8, 22, & 993 have six requirements. The jamming feature probably has extra maintenance tasks. Ws, pm, and cm should mandate EW manning requirements.

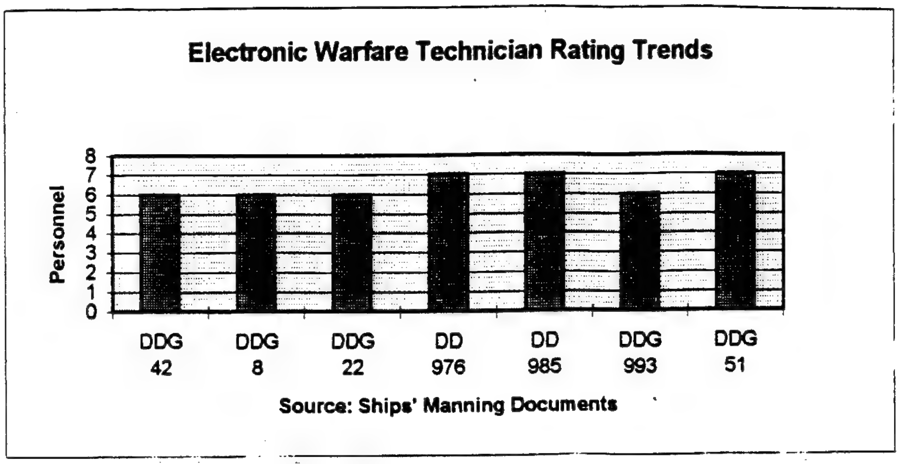

Figure 3-20 Electronic Warfare Technician Rating Trends.

9. Fire Controlman (FC) (Weapons, Combat Systems)

FC's have been segregated by specialties in either gunnery or missiles. The gun FC's show a mixed trend from DDG 42 to DDG 51 (Figure 3-21). Part of the trend can be attributed to advancements in gunfire control systems aboard the SPRUANCE class platforms and later. Part of the increase can be attributed to the addition CIWS to later platforms. The reduction of gun FC's aboard DDG 51 is due to the removal of the aft 5"54 gun. Missile FC's have also shown a mixed pattern. The most interesting note is that DD 976, DD 985, and DDG 993 have the same number of manpower requirements yet their capabilities are vastly different. DD 976 possesses eight TLAM/TSAM (ABL) and NATO SEASPARROW (BPDMS). DD 985 has TLAM/TASM from the 61 cell MK 41 VLS and NATO SEASPARROW (BPDMS) and DDG 993 possesses 2 MK 26 Standard AAW missile launchers. The DDG 51 missile FC's also perform maintenance on the AEGIS system that explains the increasing trend. In addition to maintenance, FC's

stand fire control sensor watches. Ws, pm, and cm drive FC manpower requirements aboard destroyers.

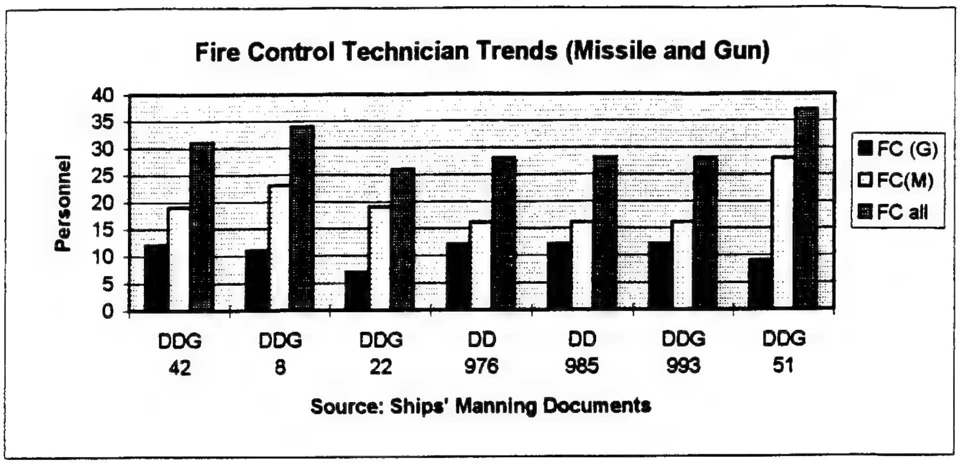

Figure 3-21 Fire Control Technician Rating Trends.

10. Gunner's Mate (Guns) (GMG) (Weapons, Combat Systems)

GMG's have seen decreases in personnel requirements as gunnery systems have become more automated and the number of gun mounts have decreased (Figure 3-22). An interesting note is how DDG 8 & 22 have the same number and type of guns and gun fire control system, yet they have different requirements for GMG's. The same holds true for DD 976 compared to DD 985 and DDG 993. DDG 42 & 51 possess only one 5 inch 54 caliber gun. The other ships have two 5 inch 54 caliber guns. The SPRUANCE class and later ships have fully unmanned gun mounts. DDG 22 has the high requirement for GMG's with 10 and DDG 51 has the smallest requirement

with 6. DDG 42, 8 and DD 976 have 8 requirements, while DD 985 and DDG 993 have 9 requirements.

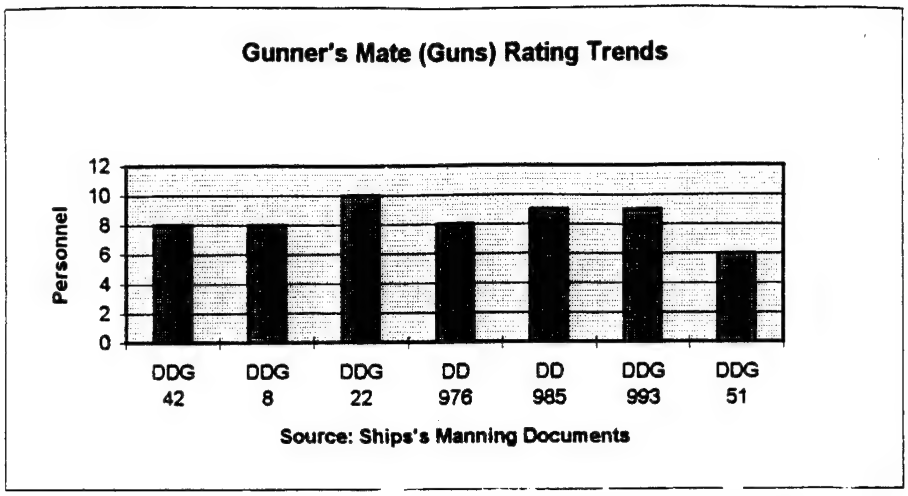

Figure 3-22 Gunner's Mate (Guns) Rating Trends.

11. Gunner's Mate (Missiles) (GMM) (Weapons, Combat Systems)

GMM manning appears to be related to the number of missiles and the age of launch systems (Figure 3-23). The older AAW DDG's have requirements ranging from 10 to 15 GMM's while DDG 993 requires 9 GMM's, have twice as many launchers, and almost fifty percent greater missile capacity. DD 976 has the smallest and least potent missile capacity and the smallest requirement for GMM's. The GMM manning requirement aboard the VLS ships (DD 985 and DDG 51) seems to be related to the total number of missiles (61-90.) DD 985 has seven requirements and DDG 51 has eight requirements for GMM.

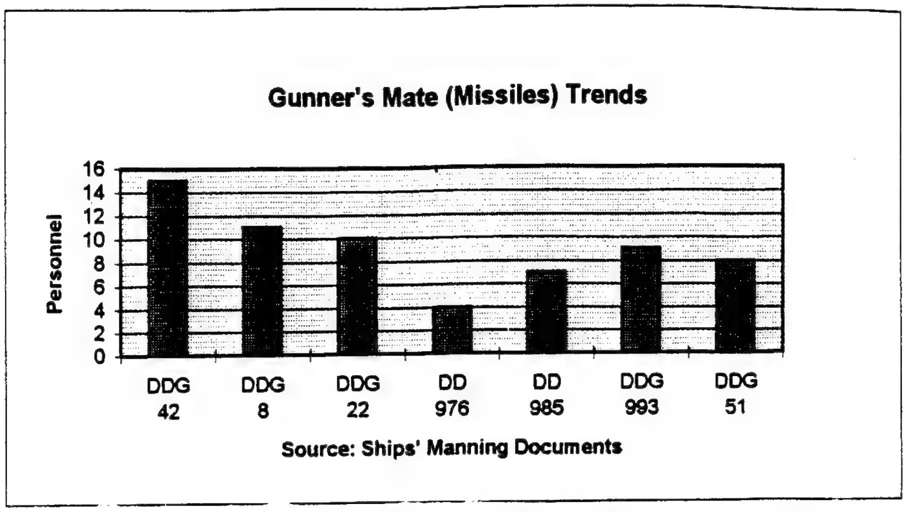

Figure 3-23 Gunner's Mate (Missiles) Rating Trends.

12. Gas Turbine Serviceman (Electrical & Mechanical) (GSE & GSM) (Engineering)

GSE and GSM requirements have remained constant throughout the gas turbine configured destroyers at eight and twenty respectively (Figure 3-15). GSE's absorbed the responsibility of maintenance on electric power generate and main engineering space electrical distribution systems, which led to a reduction in EM manpower requirements. GSM's have replaced the BT and MM (main propulsion) occupation with the evolution of steam engines to gas turbine engines. Pm and ws are the primary drivers for GSE and GSM manning.

13. Hull Maintenance Technician (HT) (Engineering)

HT trends have see sawed up and down over the years (Figure 3-24). DDG 22 has the highest requirement for HT because there are no DC requirements on that ship. HT requirements vary from 4 on DDG 42, 8, & 51 to 5 aboard DD 976 & 985. DDG 993 has a requirement for only 3 HT's. Cm

and fm are the primary tasks that push HT requirements except for DDG 22 (pm, cm, and fm).

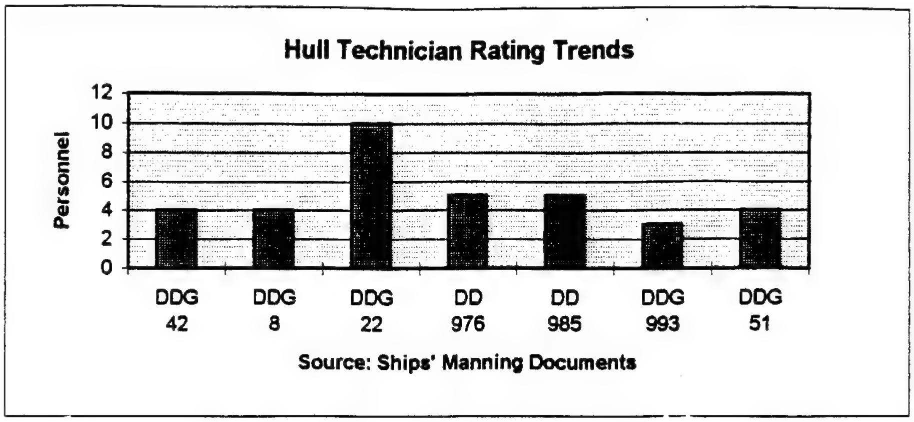

Figure 3-24 Hull Maintenance Technician Rating Trends.

14. Interior Communications Electrician (IC) (Engineering)

IC manning requirements vary from six aboard DDG 42, 8, 22, & 51 to five aboard DD 976, 985, and DDG 993 (Figure 3-25). Pm and cm push the requirements for IC manning. Though the type of equipment has evolved from analog to digital in many instances, the maintenance and manpower requirements have not waned.

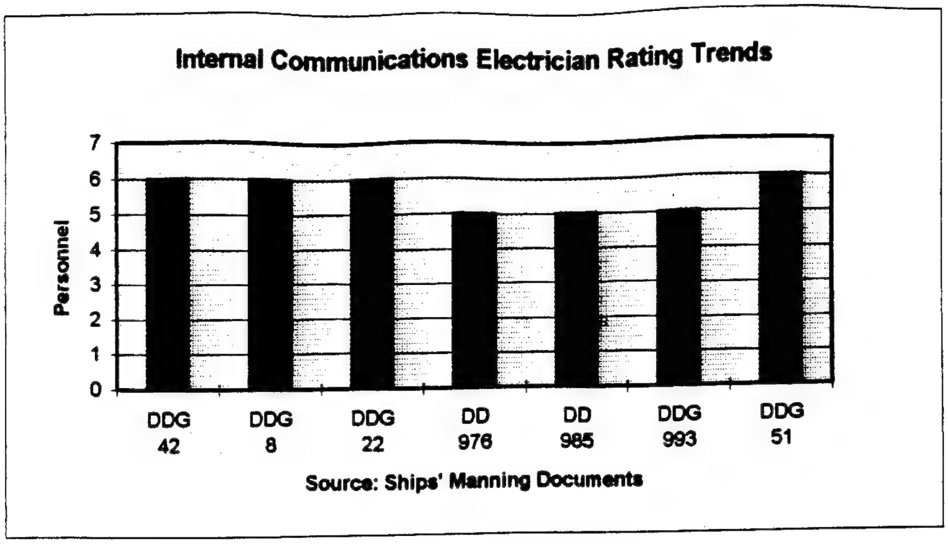

Figure 3-25 Internal Communications Electrician Rating Trends.

15. Machinist Mate (MM) (Engineering)

MM requirements were actually increasing prior to the extinction of the steam destroyers (Figure 3-15). DDG 42 & 8 had thirty-nine total MM's while DDG 22 has forty total requirements. All these ships have thirty-four requirements in main propulsion. DDG 42 & 8 have five requirements in auxiliary while DDG 22 has six requirements in auxiliary division. Ws, pm, and cm mandate MM manning.

16. Mess Management Specialist (MS) (Supply)

MS manning has vary from a high of nineteen requirements aboard DDG 22 to a low of fourteen requirements aboard DD 976, 985, and DDG 993 (Figure 3-26). DDG 42 & 8 have seventeen MS requirements while DDG 51 requires sixteen MS's. Ous determines MS manpower requirements.

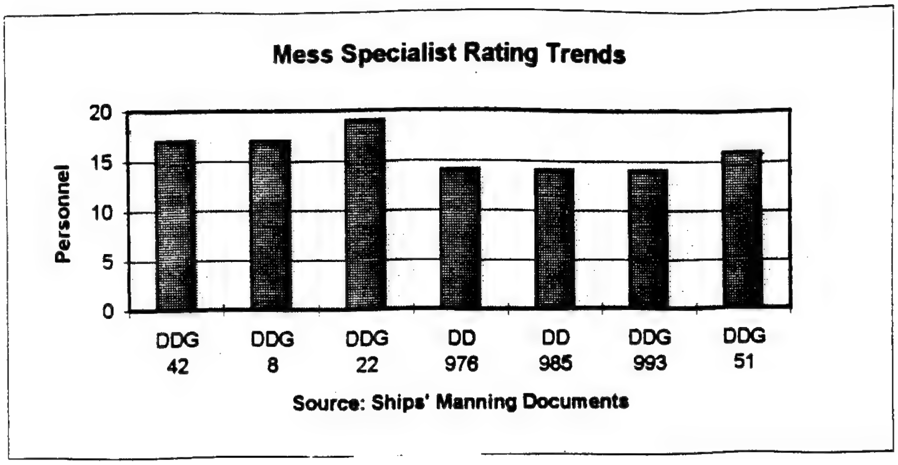

Figure 3-26 Mess Management Specialist Rating Trends.

17. Operations Specialist (OS) (Operations)

OS requirements vary according to the number of radar repeaters and tactical data consoles aboard destroyers (Figure 3-27). Manning varies from a high of thirty-seven aboard DDG 993 to a low of twenty-five aboard DDG 8. DDG 42 has thirty-four while DDG 22, DD 976 & 985 have thirty-one requirements. DDG 51 has only twenty-eight requirements. Ws is the key determinant of OS manning.

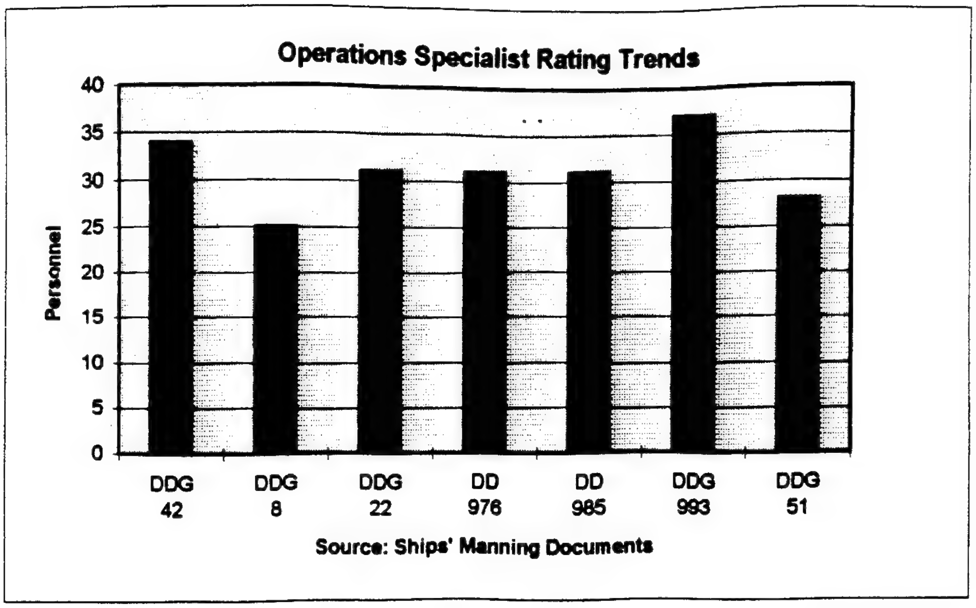

Figure 3-27 Operations Specialist Rating Trends.

18. Radioman (RM) (Operations)

RM requirements fluctuate from a high of twenty aboard DDG 42 to a low of thirteen aboard DDG 8, 22, & 993 (Figure 3-28). DD 976 & 985 have sixteen RM requirements. DDG 51 has nineteen requirements. Ws requirements, which drive RM manning, are determined by the number of personnel operated transmitter and receiver devices.

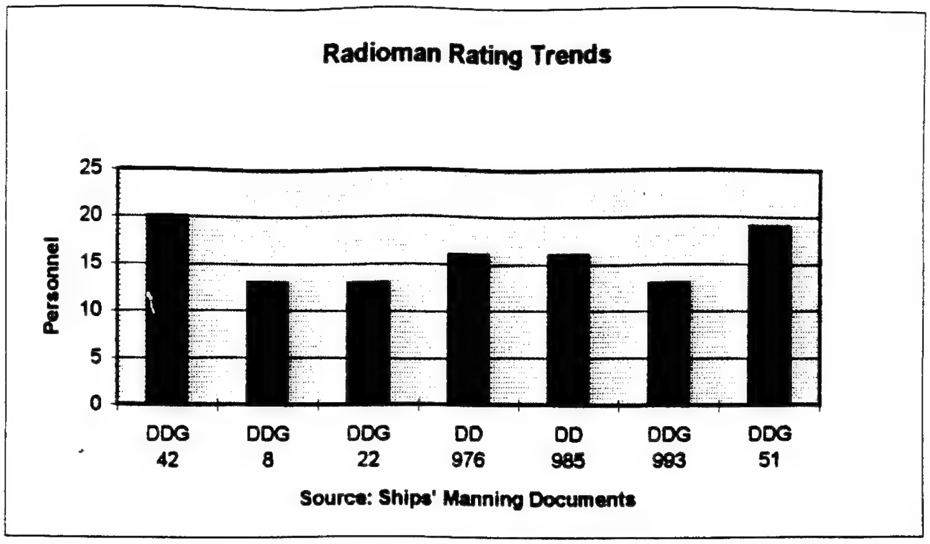

Figure 3-28 Radioman Rating Trends.

19. Sonar Technician (STG) (Weapons and Combat Systems)

STG manning requirements are sixteen personnel aboard DDG 42, 8, & 22, which have the PAIR sonar (Figure 3-29). DD 976 & 985 have SQS-53C and SQR-19 TACTAS and require twenty STG's. DDG 993 has the SQS-53C but no TACTAS and requires only fourteen STG's. DDG 51 has the SQS-53C and TACTAS and requires nineteen personnel. Ws, pm, and cm dictate STG manning requirements.

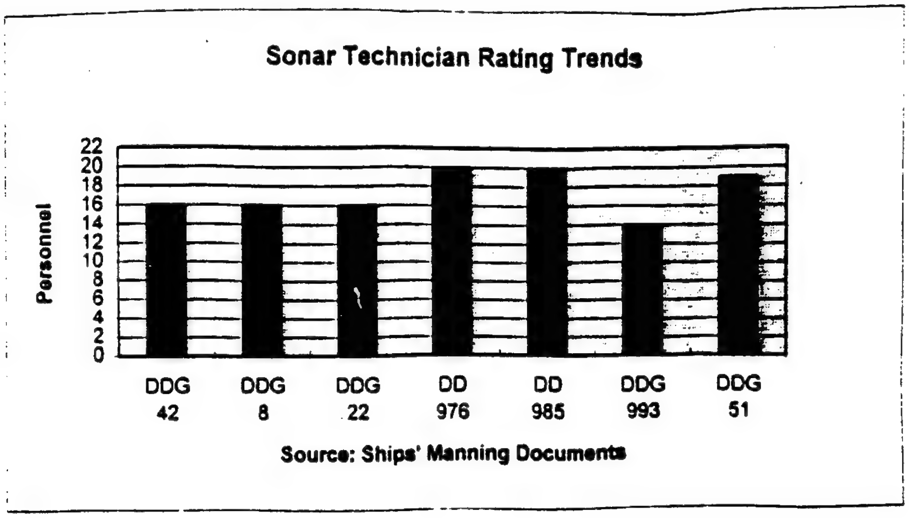

Figure 3-29 Sonar Technician Rating Trends.

20. Ship's Serviceman (SH) (Supply)

SH manning hovers from six to seven across the sample (Figure 3-30). DDG 42,8, 22. & 993 each require six SH's, while seven are required aboard DD 976, 985 and DDG 51. Ous enforces the SH requirement aboard destroyers.

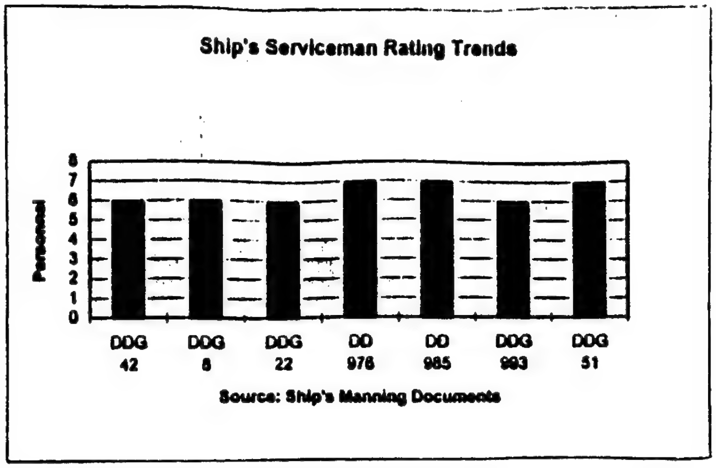

Figure 3-30 Ship's Serviceman Rating Trends.

21. Storekeeper (SK) (Supply)

SK's also perform ous and as a rule have a requirement for eight personnel. Only DDG 22 has a requirement for nine SK's (Figure 3-31).

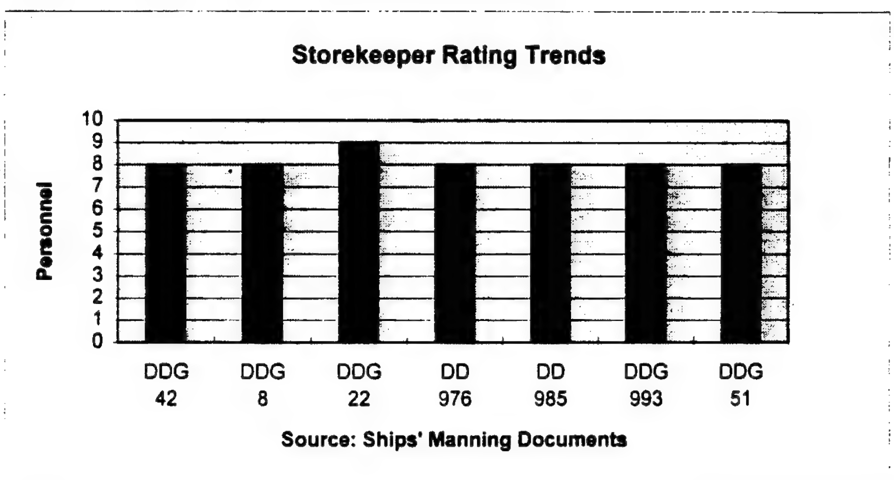

Figure 3-31 Storekeeper Rating Trends.

22. Fireman (FN) (Engineering and Supply)

FN have a declining requirement trend through the years (Figure 3-32). DDG 42 has the most FN requirements with twenty-nine. DDG 8 & 22 have twenty-three and twenty-eight requirements respectively. Steam ships have a higher FN requirement than the gas turbine ships. DD 976, 985 and DDG 993 have fifteen requirements while DDG 51 has only thirteen requirements. FN perform fm, ous, and ws functions.

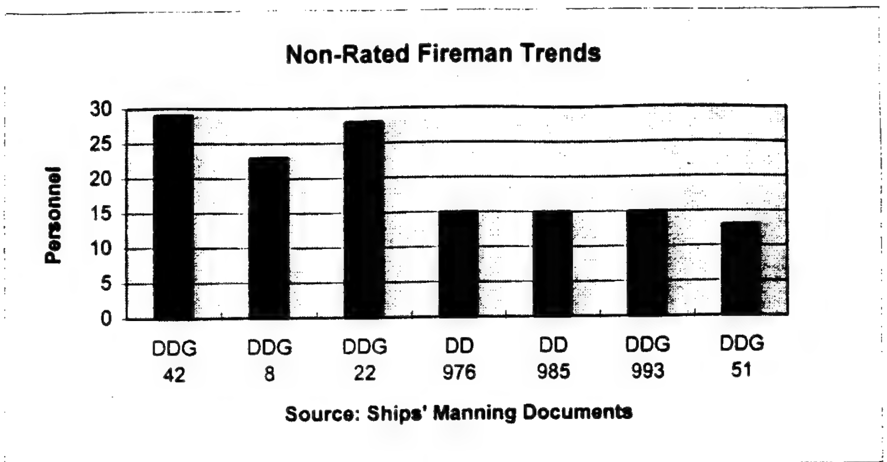

Figure 3-32 Non-Rated Fireman Rating Trends.

23. Seaman (SN) (Operations, Weapons, and Supply)

SN manning appears to be related (much like BM manning) to topside area (Figure 3-33). DD 985 has the largest SN requirement with forty-two. DDG 42, & 993 require forty-one SN. DD 976 requires thirty-nine, while DDG 51 is manned with thirty-five. DDG 8 & 22 have the smallest requirements with thirty-one SN. SN manning is dictated by fm and ous requirements.

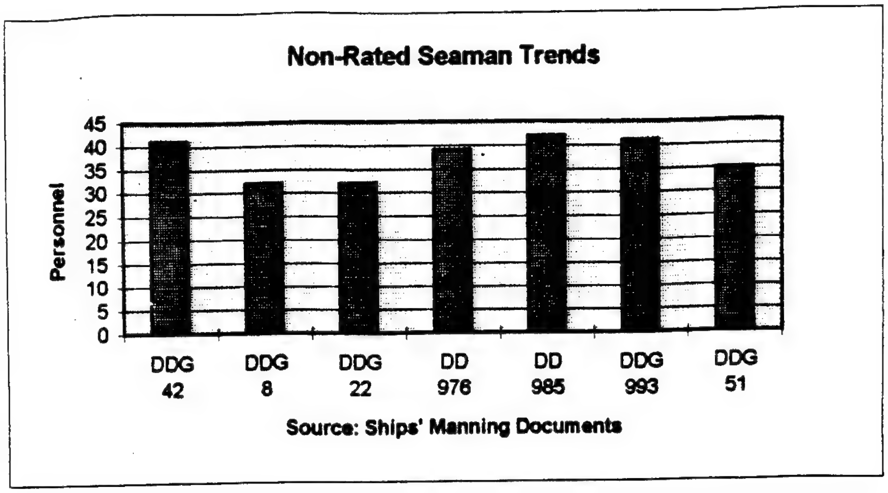

Figure 3-33 Non-Rated Seaman Rating Trends.

F. MANPOWER COSTS

This study employs the Navy Manpower Billet Cost Factor cost estimation model to determine overall personnel costs for the different platforms in the sample. The Navy Billet Cost Factor (BCF) is a computerized personnel cost model compiled and developed by the SAG Corporation for the U.S. Navy Bureau of Personnel "to enable defense contractors to accurately and consistently estimate the manpower costs of weapon systems."

- Military compensation (consists of basic pay, Basic Allowance for Quarters (BAQ), Basic Allowance for Subsistence (BAS), and Variable Housing Allowance (VHA))

- Retired pay accrual.

- Training costs (include initial training, base rating training, and specialized training).

•Selective Reenlistment Bonus (SRB) (paid on a discretionary basis to individuals of certain rates or skills)

•Enlisted recruiting (amortized Navy resources necessary to attract or recruit over the career of an individual that includes recruiters and enlistment bonuses, advertising, and processing).

•Medical support (covers fixed and variable non-pay costs that provide healthcare to members and family).

•Other benefits (include death gratuities, apprehension of deserter award, unemployment compensation to ex-service members, adoption expenses, clothing, Morale, Welfare, and Recreation (MWR) benefits, and government contribution to social security tax).

•Permanent Change of Station (PCS) (covers rotational, operational, accession, training and separation moves).

•Officer acquisition (includes advertising, scholarships, initial training, military pay, allowances, instructor costs, operation, and support costs).

•GI Bill (estimates the present value of basic GI Bill benefits at time of enlistment). This is funded by the Veterans Administration vice the DoD.

•Separation costs (accrued leave benefits, severance or disability pay, and a separation move). (BCF Operations Manual)

1. BCF Sources

All data for military compensation is extracted from Office of Secretary of Defense (OSD) pay tables, allowance tables, or RMC/BMC tables except VHA. VHA data is obtained from a Defense Manpower Data Center (DMDC) calculation of average VHA by rating and paygrade as of the end of FY 1993. (Ibid., p11) The retired pay accrual is determined by

multiplying the basic pay by fixed normal cost percentage obtained from the DoD actuary. (Ibid., p13) SRB amounts were provided by the Bureau of Naval Personnel (BUPERS). (Ibid., p14) All training cost data were provided by the Chief of Naval Education and Training (CNET). (Ibid., p16) Navy Recruiting Command provided all recruiting costs. (Ibid., p19) Medical support costs were extracted from the Medical Expense and Performance Reporting System from the Navy's Bureau of Medicine. (Ibid., p21) The "other benefits" data are found in MPN and OMN budget justification books. (Ibid., p23) PCS data are obtained from the MPN justification book and current Joint Travel Regulations. (Ibid., p28) Officer acquisition data were extracted from the U.S. Naval Academy and the Resource Manager of Officer Accessions at CNET. (Ibid., p31) G.I. Bill data compute the expected net government outlays associated with the basic benefit. (Ibid., p32) Separation costs come from the MPN Budget Justification Book. VSI, SSB, and 15 year retirement programs were not included in these Figures. (Ibid., p34)

This cost estimation method provides many factors vital in assessing manpower costs for ships and other weapon platforms. It should be noted the weakest elements in this cost data base are the officer accession and training cost elements. Another shortfall of the model is the lack of cost assessment for the Chief Warrant Officer ranks (CWO). For the purpose of this study, CWO costs will be assessed utilizing the LDO Ensign (O-1) costs. By nature of occupation, experience, accession path, and training; CWO's more closely resemble LDO's than any other officer or enlisted personnel. One final note concerning a potential

problem with the BCF data base is in the Operations Manual concerning separation costs. It appeared to the author that separation moves were listed in both the PCS module and the Separation Cost module. If this is so, then the BCF will add separation moves twice for each individual and thus provide an artificially high cost estimate for the individual analyzed. The author contacted the SAG Corporation to discuss this apparent discrepancy with the BCF developers. The SAG spokesman stated he would research the issue and update the Operations Manual. SAG estimated that the BCF only added the cost of a separation move once and that the Operations Manual had not been revised to reflect. (Mairs, 1995)

2. Cost Trends

The data reveal declining overall costs through the sample. Interestingly, the costs of the crews do not decline in proportion to crew reduction (Figure 3-34). This phenomenon can be analyzed by observing the similarities and differences in enlisted and officer manning requirements (both rating/designator and rank). The enlisted costs in this data are most influenced by training, officer acquisition, and recruiting costs that account for unusual costs in various ratings. In this case, the unusual being E-4 costs (in certain ratings) exceeding E-5 and E-6 costs. The same holds true in the officer ranks with O-3 costs exceeding that of O-4 and O-5. DDG 42 has the highest total costs of enlisted and of officer personnel with $19,879,378.04 and $2,582,806.58 respectively. DDG 51 has the lowest overall enlisted costs of $15,749,139.29. DDG 993 has the lowest officer costs in the sample with

$1,956,236.99. These costs cannot single-handedly be attributed to personnel reduction. The total numbers of combined enlisted and officer requirements have declined through the past thirty years. The total combined manpower costs of ships commissioned from 1960 through 1991 have declined from a total of $22,462,184.62 for DDG 42 to a low of $18,047,338.01 on DDG 993. DDG 51 had very high officer costs that made it more expensive than DDG 993 in terms of total combined manpower costs. The manning cost reductions over the sample appear related to the differences in costs through the various departments and required officer designators and ranks. These requirements are a result of the various equipment and systems employed on the various platforms.

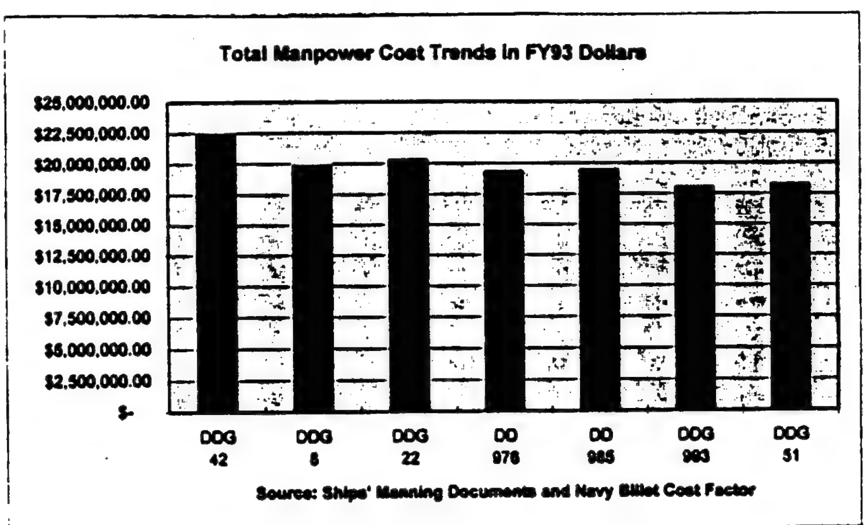

Figure 3-34 Total Manpower Cost Trends.

A closer look at the Figures show that some departments have seen reductions in costs, some have remained the same, while others have seen increases over time (Figure 3-35). The Navigation and Medical Departments have seen constant personnel requirements and costs using FY93 costs as a base. The Executive Department has shown slight ups and downs in personnel and costs over the years. The Operations Department has shown a some increase over time depending on how the department is organized. Adding deck division raises the costs. Outboard capable ships (DD's) have even higher costs. Weapons departments are more costly than Combat Systems Departments (as a result of deck division). Both show a decreasing cost trend which can be partially attributed to personnel reduction. Also showing vast personnel numbers reductions, Engineering Departments have seen the greatest cost reductions over. This is directly attributable to the transition from steam to gas turbine systems. Supply departments have shown small decreases over time. The departmental costs are dependent on the respective divisional costs and the respective ratings and ranks of requirements that compose them.

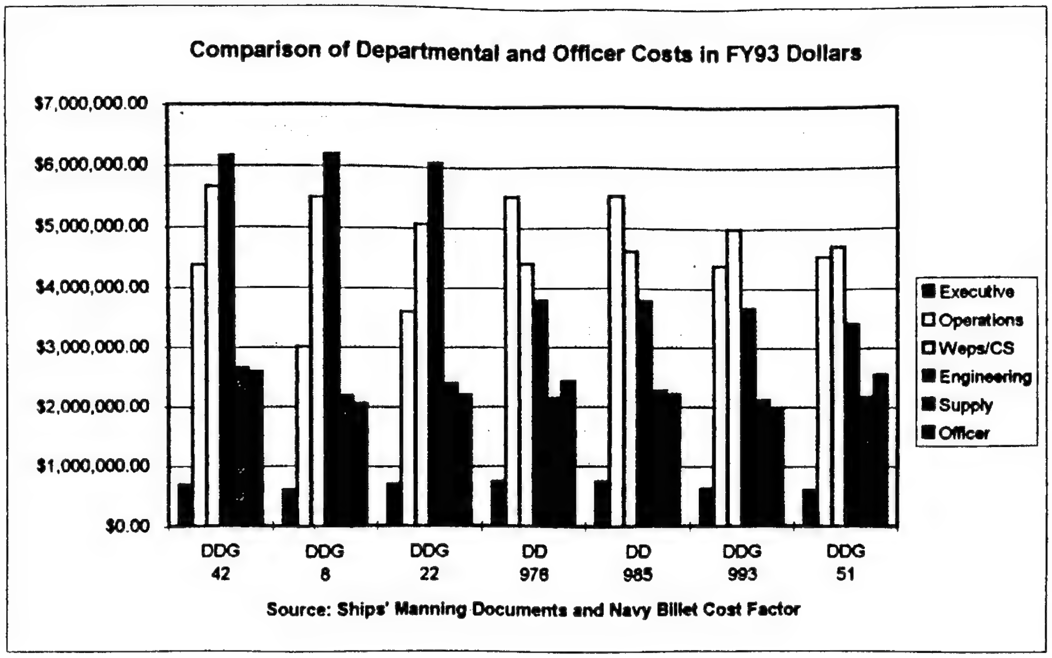

Figure 3-35 Departmental Manning Cost Trends.

IV. THE AUTONOMIC SHIP

This chapter will discuss broad technical possibilities of the next generation U.S. Navy destroyer. For the purpose of this study, SC 21 will serve as an abbreviation for the next generation destroyer. Concepts for the SC 21 were first formulated by the Navy in 1988. This study, entitled Ship Operational Characteristics Study (SOCS), analyzed and debated the various desired features to meet the anticipated needs of the next generation destroyer. In 1993, the Naval Surface Warfare Center Carderock Division, Bethesda, MD (NSWC) presented a proposed concept of the next generation destroyer to meet the Navy's twenty first century commitments. NSWC aspired to "synergize" unified warfare and united support systems (hull, mechanical, electrical and logistical) using high performance distributed computing networks to introduce the Autonomic Ship. Autonomic is a term coined from medical terminology that describes the involuntary nervous system. The objective of this warship concept is to optimize the "man to machinery" mix. This optimal mix should offset higher capital investments and yield great personnel cost savings. NSWC sees new computer technology interfacing with improved mechanical, electrical, and robotics technology to make the Autonomic Ship a possible and plausible candidate as SC 21. RADM David Sargent, Commander of the Naval Surface Warfare Center made a comment adding that the "twenty first century combatant will most likely be built on a DDG 51 hull." (Sargent, 1994) Autonomic technology should allow reductions in manpower and increases in weapon system capabilities in future classes. The resultant goal is a class of less manpower intensive and more capable weapon platforms to put

"ordinance on target." The major Autonomic Ship highlights with respect to manpower requirements will be discussed in this chapter. The following subject areas were described: the computer backbone, ship control, machinery control, damage control, maintenance, warfare, logistics, administration, communications, and training.

A. COMPUTER BACKBONE

The Autonomic Ship will employ coordinated concepts such as ubiquitous computing systems (computers everywhere), fault tolerant systems, and software objects. When these qualities are combined into a huge system, they will provide tasking and function analysis. Hypothesized interfaces for the computers include voice, pen, virtual reality, desk top consoles, etc. The planners anticipate an unmanned universal operating system more advanced than current "open standard" systems that utilizes object libraries linked by intelligent agents in place of existing third and fourth generation digital language systems. Software advances are projected to be an extension of current object oriented setups (for example, MS Windows) using agents vice objects. Current object oriented software employs the following protocol to execute desired functions: interface, algorithm, and data structures. The agent oriented system will make use of the process as object oriented software except that that the agent oriented software will employ a context filter to allow greater flexibility and interface possibilities. (NSWC, 1993) Hardware emphasis in the ubiquitous computing concept involves numerous computer nodes throughout the ship with many processors to provide enough capacity and redundancy to keep the entire system "effectively invulnerable to battle damage." (NSWC, 1993)

The computing backbone will provide the vast majority of decision making and minor execution in the areas of the ship. Through coordination with sensors and effectors, the computing backbone can store, process, interpret, and display real-time filtered information as opposed to raw data. The planners emphasized a desire for fault tolerant yet reconfigurable computers. The systems must ensure computing, redundant storage and retrieval capabilities. Other planned features include ergonomic consoles, high definition television, direct interactive controls, 3-d volumetric displays, virtual reality, and personal access display devices (PADD) (for example, Apple Newton, and AT&T Personal Communicator). (NSWC, 1993)

B. SHIP CONTROL

The Autonomic Ship is expected to employ a command Center that combines the Bridge and CIC in an enclosed, centralized, and protected area. The designers ideally desire 360 degree view screens to allow vision of the environment as if being outside the ship. Television, low light television, infrared, radar and imaging sonar can be developed to make this a reality. Navigation can be provided using improvements in the already existing global positioning system, inertial navigation system, and visual fixes. The navigational systems can be interfaced with future weapon systems for targeting information. (NSWC, 1993) The media inputs can be simultaneously placed on electronic charts. The charts can also be updated electronically via external communication devices. Additional technical additions include an "enhanced auto-pilot" that will be linked to the self defense and navigation systems. Ideally, the auto-pilot will be able to

"flinch." The auto-pilot will feature various modes such as patrol, piloting, and a coordinated zigzag. The auto-pilot will be able to perform underway replenishment piloting while alongside other ships by employing laser range finders and a data link to provide safe ship handling actions. (NSWC, 1993) Current technology exists to far surpass the IBS navigational suite tested aboard USS MCCANDLESS that would have yielded an approximately fifty percent reduction in bridge manning under most circumstances.

C. MACHINERY CONTROL

The Autonomic Ship will feature a Central Control Station (also a Command Center) as the propulsion plant and auxiliary machinery monitoring station. The new features anticipated by the concept team are machinery control from any device and tele-presence of all machinery spaces. (NSWC, 1993) Robotics technology will make this idea feasible. In addition to monitoring, the robots may perform mundane maintenance, operations, and initial casualty or damage control actions. The computer backbone is projected to provide monitoring analytical capacity of propulsion, power generation and auxiliary equipment. This capacity will allow unmanned engineering spaces and remote configuring of auxiliary systems. The Autonomic ship brief did not introduce any new methods of propulsion or power generation. The computer backbone will provide decision aids to help determine optimal operation of equipment. Designers project the systems will perform "smart paralleling" and damage or failure recovery. This will lengthen equipment operating time and capabilities.

D. MAINTENANCE

Designers stress moving away from time based maintenance, stressing condition-based maintenance instead. The computer system is foreseen to have software that can provide on-line machinery condition assessment. The maintenance software programs could predict time to failure and allow maintenance personnel to perform predictive maintenance and optimize maintenance man hours. These programs can also make possible rapid readiness assessment. In the future repairs can be streamline using electronic equipment configuration management and using a PADD that will view an integrated electronic technical manual for a particular component. In the event of difficult repairs, teleconferencing with the original equipment manufacturer can replace expensive technical assist visits of the past. Redundancy in the fault tolerant system will theoretically reduce the maintenance urgency aboard the Autonomic Ship. (NSWC, 1993)

E. DAMAGE CONTROL

The Autonomic Ship is projected to be designed for toughness using distributed fault tolerant systems. Designers recommend building fully habitable citadels (hardened structures) that are centrally located inside the ship to provide a safe haven for personnel prior to engaging the enemy. The unmanned spaces will be inerted with a non flammable gas to remove or greatly reduce the likelihood of fire after a battle hit. Finally the ship should be constructed using blast hardened structures. (NSWC, 1993)

In battle, the designers propose employing "proactive damage control" using weapon sensors to predict where hits may occur prior to impact and automatically reconfigure

equipment to ensure reliability. Once the hit is received, the ship sensors and computing system can perform a rapid damage assessment much faster than is currently possible. After the assessment, the system will prioritize the severity of damage and determine what to fix first. With the hardened and distributed computer and robotics systems, remote isolation will occur quicker to suppress fire and flooding.

F. WARFARE

The Autonomic Ship will be configured to deal with the war fighting tasks at hand. The system will reconfigure for battle damage and failed items. The system will create new inter-connection paths of sensors to computer to weapon engagement systems. (NSWC, 1993) New levels of automation will surpass existing automation through improve combat systems integration. The "open" systems will allow extension and inter-operability between currently incompatible systems such as radar, electronic warfare, and sonar, etc. These advances will better aid warriors in "hard kill" (sinking an enemy ship) and "soft kill" (disabling an enemy radar system).

G. LOGISTICS

Computer Aided Logistics System (CALS) will streamline maintenance at the ship, intermediate, and depot levels. The Autonomic Ship should allow for paperless maintenance by using automated job entry and integrated electronic technical manuals. These features are projected by designers to yield man-hour savings. A ship to shore or destroyer tender data link to prearrange repair services should improve logistical efficiency. Inventory control can also be improved using an automated worldwide parts

availability and ordering system via data link using existing national stock numbers or original equipment manufacturer numbers. The next data base improvement will involve bar coding components and equipment. (NSWC, 1993) This will vastly improve the efficiency in the existing configuration management system in the fleet and reciprocate into improved fleet maintenance.

H. ADMINISTRATION

Designers foresee shore based administration data bases that be updated using on-line transaction procedures. These procedures will be used for personnel, pay, medical, and dental records. These configurations will remove the requirements for departmental yeomen because of computerized technical manuals and logs. The other administrative personnel will be transformed into data entry and retrieval specialists. (NSWC, 1993)

I. COMMUNICATIONS

External communications will be performed using the fully automated Copernicus System that is very versatile in frequency selection. The system performs transmission over the entire Navy's radio communication spectrum whether satellite, VHF, HF, etc. (NSWC, 1993) Internal communication will be performed using active transmitter devices for each crew member that will make possible instant personnel location. This capability will greatly assist in man overboard or other danger situations. The improvements in internal communication will involve information routing between consoles and command centers. The system can also optimize between video and audio communications. (NSWC, 1993) This will eliminate a need for phone talkers between stations.

J. TRAINING

The Autonomic Ship computer system will feature embedded training. The embedded training will be accessed from any station and interactive. This training could allow shortened school pipelines for personnel prior to arriving on the ship that could lead to future personnel cost reductions. Personnel may become more motivated to train and cross-train. (NSWC, 1993) Overall crew readiness should improve in the respective areas (given the pertinence of the training). Designers predict that training will be a managed asset. This asset will become an important part of workload planning. In the future, the training system aboard the Autonomic Ship will be capable of providing a readiness assessment for the entire ship. (NSWC, 1993) This would eliminate a need for inspections by higher authority. If the computer has all of the training data bases and standards of objective criteria, it could perform the inspection. The chain of command could access the individual ships' latest self generated training assessment.

K. PROPOSED MANNING REQUIREMENTS (FROM THE DESIGNERS)

The designers for the Autonomic Ship hypothesized that manning requirements will be drastically reduced in comparison to existing ships. The designers suggest that 101 officers and enlisted persons will be needed to operate the ship in battle. (NSWC, 1993) Of the 101, thirteen are officers and eighty-eight are enlisted. The designers propose a different organizational structure from existing practice (Figure 4-1). The hierarchy consists of a commanding officer and four department heads. The departments will consist of information, combat systems, engineering, and supply. (NSWC, 1993) Designers foresee the

information department to be composed of a computer division with one officer and three enlisted persons (1 DS, 1 DP, and 1 E4 of any rate). A human resources division will replace the existing executive department with one officer, and five enlisted personnel (1 PN, 1 YN, 1 DK, and 1 E4 of any rate). In the Autonomic Ship concept, the communications division will also be in the information department. The division will have one officer and ten enlisted crew members (8 RM and 2 SM). Finally, one chief petty officer will be employed in the medical division, which will also be included under the information department. The combat systems department will possess a sensors division, a weapons division, and an operations division. These divisions will all have one officer assigned. The sensor division is projected to have twelve enlisted assigned (4 STG, 2 FC [guns], and 6 FC [missiles]) The weapons division should have five enlisted personnel (2 GMM, 2 GMG, and 1 TM). The operations division is foreseen to have twenty-three enlisted personnel (12 OS, 4 EW, 3 ET, and 4 BM). Designers see the engineering department as having only two divisions, mechanical and electrical. Each division will have one officer assigned. The mechanical division will include nine enlisted persons (1 DC, 4 MM, and 4 GSM). The electrical division will include eight enlisted members (3 EM, 3 GSE, 2 IC). The supply department will be composed of two divisions also, food service and parts. Designers see the divisions to be headed by chief petty officers (MS and SK respectively). The food service division will be composed of seven additional enlisted persons (6 MS and 1 SH). The parts division will have an additional three enlisted crew members (3 SK).

Designers also included a proposed watch bill that theoretically could support four watch sections. This watch bill required sixty personnel to staff the listed watch stations. (NSWC, 1993) The watch bills included the "bridge/CIC" Command Center and the engineering Command Center. Considerations for manning were made given the designer's constraints and not those of current Navy manning practice.

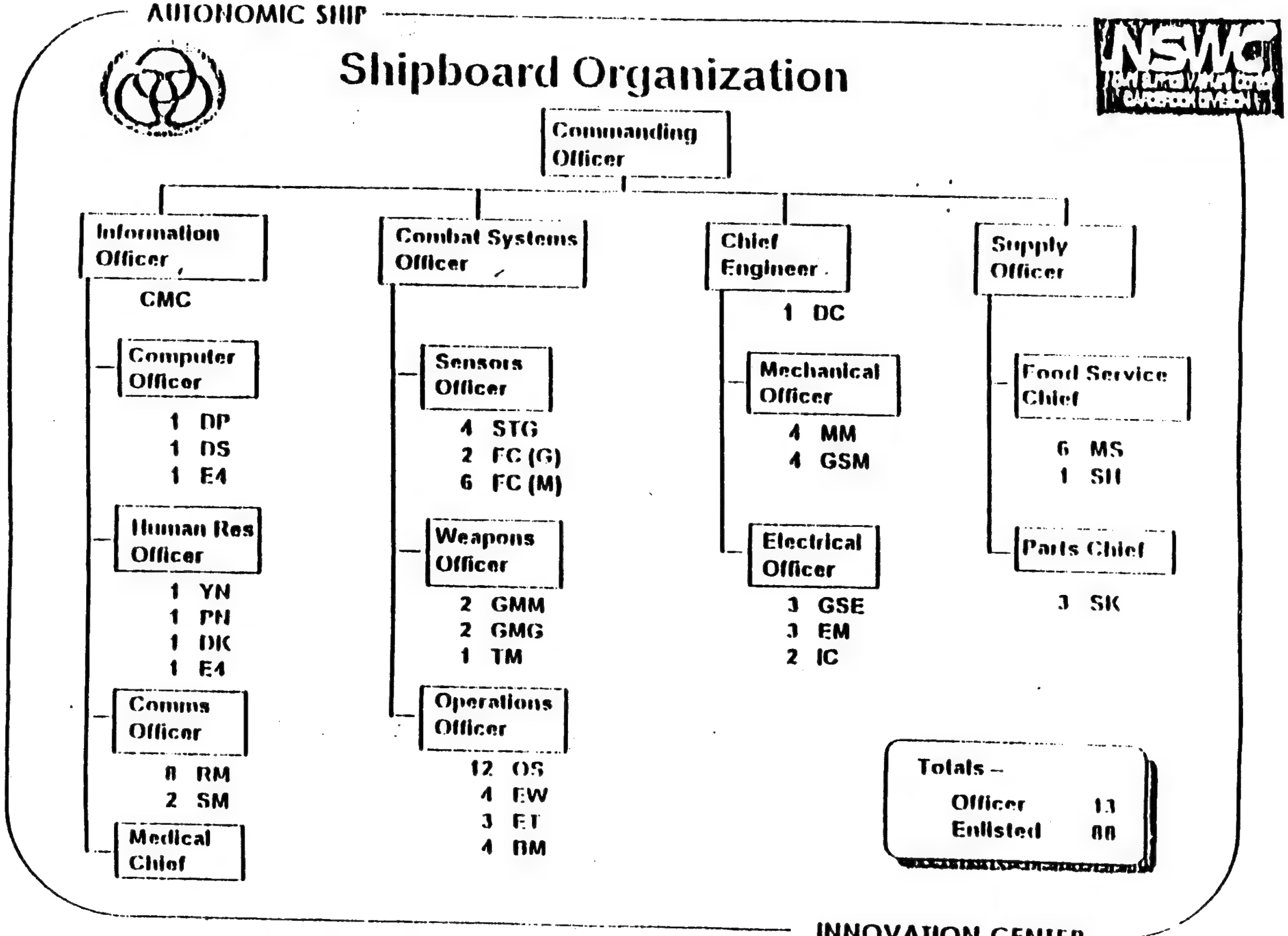

Figure 4-1 Autonomic Ship Organization and Requirements.

L. WRAP UP

The Autonomic Ship demonstrators presented a concept of ship based on projected improvements in systems engineering, information technology, and relaxed organizational requirements. No improvements in weapon systems or engineering equipment were listed in the briefing. Designers hope to prove that destroyers can be operated safely and reliably under the new manning and maintenance concepts with significantly fewer people. The development team hopes to show the departmental officials that the Navy can meet mission requirements for less money. Keys for these savings will come through advanced information processing and automation.

Other presentations by similar research entities have presented similar warship concepts with advancements in mechanical and electrical technology. Some of these concepts include proton exchange membrane (PEM) propulsion. (ARPA, 1994) Weapons research is ongoing in the field of "directed energy" laser guns. These are but two possible leaps in technology that may impact projected ship manning by the 2003 estimated start date of constructing the next generation U.S. Navy destroyer. As discussed in Chapter II, if a new technology for visual LOS communication is employed by the Navy by 2003, then the ship can be designed differently and alter manning requirements.

V. MANPOWER REQUIREMENTS

This chapter synthesizes the information listed in Chapters III and IV to yield manpower requirement estimates of the next generation destroyer. Many possible scenarios may unfold prior to developing and building the lead ship. The initial construction of the new class is tentatively planned to begin in 2003. (Huchting, p49) It is fair to say the actual manpower requirements and costs will be based upon the subsequent determination of the most appropriate scenario. The three scenarios discussed will describe the manning requirements and costs in FY93 dollars, arguments supporting possible policy, and ramifications to be considered. The ship development scenarios that may occur are:

1. The information technology ideas of the Autonomic Ship have not matured or proven fruitful enough in operational development and testing phases by 2003. The lead ship will be built only with advanced information processing systems and transaction processing features. Other ship systems remain similar but are incrementally improved over DDG 51 systems. Current organizational (administrative and maintenance) policies remain intact.
2. Information technology ideas of the Autonomic Ship mature and prove fruitful during operational development and testing. LOS visual communication devices are developed by 2003 and employed Fleet-wide by 2010. Other ship system configurations remain similar but are incrementally improved over DDG 51 systems. Organizational policies remain intact.

3. Information technologies mature and autonomic technology is employed. Mechanical and electrical technologies have allowed new forms of propulsion and weaponry to be exploited aboard the new ship class. Organizational policies become relaxed through advances in communication technology. Maintenance management adapts condition-based practices.

A. BACKGROUND

New technologies can have an impact on future manpower requirements. This can be best analyzed by looking at the effects that these technologies will have on operations and maintenance of military systems themselves and on the infrastructure. (Binkin, pp. 39-40) A major limiting factor in this study is projecting technical advances over the next eight to ten years. The technology will have a tremendous impact on manpower requirements. The tendency has been to underestimate manpower needs for future systems. (Binkin, p40) The Navy has many administrative and organizational constraints that add to shipboard personnel requirements. For example, the Navy uses the U.S. Postal Service and other parcel delivery entities in delivering mail and supply parts. The Navy also provides extensive counseling for enlisted personnel in broad career development, advancement, and transition to civilian life. Physical security requirements aboard ship require many man-hours of labor intensive administration and presence to ensure order. Navy maintenance practices employ periodic and conditional actions to guarantee proper equipment reliability. Historical case studies have shown many of the time-based maintenance procedures worthwhile.

The Navy has experienced problems in underestimating manpower requirements in the 1970's with several ship classes. One problem involved the DD 963 class, was building the warship with too few weapon systems. A problem with the FFG 7 class surfaced when the Department of the Navy arbitrarily mandated the berthing (crew living quarters) capacity. This was done to meet acquisition costs without fully accounting for maintenance and watch-standing work loads. (GAO, 1981, p33)

In the 1970's the Navy adopted a weapon system (ship) substitution mix entitled High-mix and Low-mix. This strategy refers to the need for highly capable and high-cost cruisers and destroyers to serve in areas of severe enemy threat. Less capable and less costly ships (frigates) were expected to operate in areas where the enemy threat is less intensive. (GAO, 1981, p1) The designers of the Autonomic Ship concept seek to integrate information technology and reduced organizational burden to substitute for manpower thereby reducing budgetary woes of the future Navy. Unfortunately with the reductions in ship personnel allowing only minor maintenance, the shore maintenance establishment must be adequately staffed to perform the additional maintenance beyond the ship's force capability. This situation will likely resemble the Low-mix concept currently employed with the FFG 7 class maintenance plan. This possibility, however, may be a higher risk alternative than current fleet destroyer maintenance practices. According to the designers, the Autonomic Ship should allow capital-labor substitution and "increased" combat effectiveness. Mechanical and electrical technology advances will prove advantageous and complementary to the

initial autonomic concepts. However, maintenance requirements will not simply vanish. Though some maintenance actions are quickly added to the fleet as a "reflex" reaction for "safety reasons," most maintenance practices in the fleet have evolved in a somewhat systematic manner based on data analysis.

B. SCENARIO ONE

1. Assumptions

This situation reflects the worst case scenario in technical development of SC 21. SC 21 will likely be as capable as or more than DDG 51. SC 21 will employ similar weapons and engineering configuration to DDG 51. This scenario assumes that the Navy is able to exploit office automation technology and on-line transaction processing for personnel and supply parts. Though artificial intelligence is employed, it has not reduced watch station qualifying time or time required to perform divisional training. Electronic Navigation system has greatly reduced QM workload. Unfortunately, the Navy requirement for manual chart keeping prevents reduction in QM personnel. The current Navy policy mandates that manual charts will be kept to ensure constant certainty of the "navigational picture." This scenario also assumes that original equipment manufacturers are unable to design and produce common digital interfaces for all monitoring and controlling equipment via a distributed computer prior to construction. The maintenance interface will prove cost effective in reducing trouble shooting time. Cost savings will come from reduced technical assist visits. However, the interface fails to reduce personnel requirements.

2. Manpower Requirements and Costs

The Executive Department will see the largest personnel reductions as a result of office automation improvements. All departmental yeomen requirements will be eliminated Supply department will see a drop in SK requirements as CALS will reduce paper work burdens drastically in logistical functions. RM requirements in the Operations Department will see reductions as a result of improve systems integration. In this scenario, the Combat Systems Department will not see a significant reduction in personnel without a corresponding drop in material and combat readiness. The Engineering Department will also not see a decline in personnel requirements.

Officer manning will change very little in scenario one. The only changes are in quality of junior officers. The LDO officer requirements will be substituted with line junior officers and a Chief Warrant Officer.

The total enlisted compliment of SC 21 will be 305 enlisted personnel and twenty-three officers in this scenario as seen in Figure 5-1. The total personnel requirements' cost of the SC 21 based on the mix in Appendix B are $17,989,437.48 (Figure 5-2). These numbers reflect an overall reduction in ten enlisted personnel and zero officers. The change in designator requirement for officers allows a slight reduction in officer costs. Unfortunately, the enlisted crew members who are lost in the requirement reduction are relatively inexpensive compared to those who are retained.

3. Arguments and Ramifications

This scenario represents a grim picture of ship development and acquisition by 2003. Scenario one will

become a reality if the information technology synthesis is not managed efficiently. This situation will also occur if original equipment manufacturers do not rise to the task. They must develop standardized digital signal converters for command and control of equipment using a common fiber optic data and distributed processing network. Another major item will make this scenario likely is caution on the part of policy makers. Even with digital excellence, warfare commanders are skeptical of the risks involved with buying expensive weapon systems that can be pilfered or sabotaged by magnetic fields, electro-magnetic pulse (emp), or a computer hacker. The commanders may argue that though the technology is magnificent, the risks far outweigh the benefits.

If scenario one becomes reality, then the Navy can anticipate high demand for junior sailors to maintain staffing for warships. This picture actually projects the least change from the status quo of ship manning requirements. This situation will yield a relatively disappointing outlook for budget planners depending on the construction costs. Given a peace-time scenario, fewer of these relatively labor intensive ships will be built than they will be replacing (DD 963). This scenario could lead to postponing SC 21 construction and reverting to a High-mix and Low-mix strategy again.

C. SCENARIO TWO

1. Assumptions

The SC 21 will be the Autonomic Ship with DDG 51 mission capability. The Navy still maintains traditional organizational requirements. The engineering and combat systems suites are highly automated. Unfortunately, enough

reliable equipment operating data have not been collected to ensure enough equipment reliability. Watch standing requirements are significantly reduced. Interactive computer training does not prove to be a panacea for instilling knowledge in shipboard personnel. Copernicus is fully employed and proves to be a very reliable and labor saving communications system. The high performance distributed computing network proves to also be maintenance intensive in terms of hardware and software. Policy makers in the design process will determine that human interface in the tactical decision process is necessary for safety reasons. A new LOS communication system is successfully implemented and proliferates throughout the fleet. The bridge and CIC will be integrated.

2. Manpower Requirements and Costs

The Operations department will see the largest reduction in troop strength as a result of the autonomic revolution in this scenario. RM requirements are significantly reduced as a result of the Copernicus automated system. The six SM requirements are eliminated as a result of the new LOS Communication system. The ET requirements shift back to Operations Department because they will only maintain Operations Department equipment. The OS requirements are directly related to the number of consoles that require human monitoring. EW requirements will reduce as the gear can now be monitored through a common digital network monitored by the OS or EW personnel. The BM rating will be least influenced by autonomic technology. The SN rating will see lower numbers due to reduced look out requirements from the integrated bridge and CIC command center.

The Combat Systems department will feature a new division, the Computer Division. The division will be divided into two work centers: Hardware (DS rating) and Software (data processing technicians DP rating). The DP personnel will manage the software distribution, programming function, and user support needs common with complex computer systems. The DS rating will perform traditional maintenance and troubleshooting efforts as with past destroyer generations. The department will see a small decrease in personnel. FC and STG personnel requirements should drop due to the data interface into a unified digital system. Sensor maintenance will keep requirements higher than projected by the Autonomic Ship briefer.

The Engineering Department will experience reduction in watch standing requirements as a result of robotics. On the other hand, maintenance requirements will not decrease as the robots demand monitoring and preventive maintenance. The department will see reductions in the number of GSM personnel. Unfortunately the number of damage control equipment and sensors will increase and must be maintained. Damage control readiness will never be higher in the fleet aboard fossil fueled ships. Personnel reduction savings will not be reaped as advertised by designers because of organizational constraints imposed by the Department of the Navy. Arguably, the SC 21 is the most cost effective and battle ready platform to sail the high seas.

The officer population will see twenty-one requirements divided along traditional lines. Officers will pilot, fight, and control the ship. A medical doctor is still required aboard the SC 21 for war. This scenario also requires two Supply Corps officers aboard the ship. Junior

officers will still report aboard as trainees. Three LDO or CWO requirements will exist in this scenario for technical expertise.

Total enlisted requirements will total 220 for the SC 21 in this projection as reflected in Figures 5-1 and 5-2. The enlisted costs are estimated at $11,123,472.81 with the given quality mix. If this scenario materializes, this will be the least expensive destroyer built since 1960 in terms of personnel costs. The officer costs are projected at $2,325,309.76. The combined officer and enlisted costs are $13,448,782.57.

3. Arguments and Ramifications

This scenario presents a more likely technical picture in the first decade of the twenty-first century. Even with the foreseen organizational constraints, significant savings can be for seen in FY93 dollars. One must keep in mind that certain policies are not going to disappear for the sake of engineering (or in some cases military) efficiency. It is reasonable to predict that ships with greater than 100 personnel will have traditional administrative suite of executive assistants (MA, NC, PC). They will assist the Executive Officer in his barrage of keeping the ship's bureaucracy functioning. Also it is likely the QM rating will remain in force (though at reduced numbers) because the rating constantly practices critical maritime techniques. In the event of loss of data processing capabilities, this rating will still be able to ensure competent assistance to the officers who will "steer" the ship. Demand for the DP personnel will almost certainly rise. The DP's will be trained to manage and train personnel on computer software. They will possess very marketable skills that will probably

increase their cost to the Navy over time. Though this ship is highly automated, there will still be large numbers of mechanical systems that will require maintenance and monitoring to support operations. This fact will keep certain mechanical ratings in high demand (DC, EN, HT). Also, high skilled electronic workers will be needed to maintain certain computer operations, weapons, and engineering equipment (DS, ET, FC, GSE).

Though the actual raw numbers of shipboard personnel requirements are declining, the Navy will still need large numbers of people. The Navy will continue to need high quality personnel to train in the high skill jobs. This could easily translate into higher recruiting and SRB costs depending on many factors. Some of these factors include operating tempo, personnel rotation policies, attrition rates, etc.

D. SCENARIO THREE

1. Assumptions

SC 21 is constructed exploiting autonomic technology. A new directed energy laser gun and PEM propulsion are developed and employed aboard the ship. SC 21 will also have VLS missile capability with similar capability and mission of the DDG 51. The U.S. Navy relaxes its administrative policies and modifies the fleet maintenance policy to a condition basis. The ship is reorganized functionally into four departments. The Operations Department will encompass the Executive, Medical, and Navigation Departments. The other departments remain as Combat Systems, Engineering, and Supply and they will perform traditional functions. Though administrative

policies are now relaxed, the numbers of programs, policies, and reports have not declined.

2. Manpower Requirements and Costs

All of the departments see an overall drop in personnel. The administrative positions remain to ensure "law and order" and personnel counseling (MA and NC). The Operations Department is still dominated by the requirement for OS personnel to staff tactical consoles and deck seamen to preserve the topside areas and perform manual labor. The Operations Department has absorbed the computer software management personnel (ADP Division with DP and one DS) and an internal communications work center (IC rating.) The former Executive departments are now the Human Resources Division.

The Combat Systems Department is now composed of three major "elements." The divisions are Sensors (search and fire control radar, sonar, and electronic warfare), Computer Hardware, and Ordnance (gun, missiles, and torpedoes). The Sensors division is composed of the following ratings: ET, FC, STG, EW. The Ordinance division is composed of the GM and TM ratings. The laser gun could likely bring about a new sub-rating in the gunner's mate rating, gunner's mate electrical or laser. The maintenance skills will probably be electrical and electronic intensive tasks in addition to some mechanical tasks. The gunner's mate guns rating is more mechanical and hydraulic task intensive with only minor electronic labor requirements. The FC and STG ratings will experience some reduction in requirements due to removal of many time based maintenance tasks. The ET and EW ratings will probably not experience as much relative reduction in strength as the FC and STG ratings. This is because the

hypothesized reductions obtained through application of autonomic technology reduced the requirements to an acceptable minimum. The GM rating will see significant reductions from the previous scenarios based on the periodic maintenance change.

The Engineering department will see some unusual changes in the main propulsion ratings. The GSM and GSE ratings will be replaced by the MM and EM ratings. The author assumes that the PEM propulsion is a form of cold fusion nuclear propulsion. (ARPA, 1994) If nuclear qualified personnel (MM and EM) are required, then the Commanding Officer and Chief Engineer must be nuclear trained officers. This scenario assumes that traditional nuclear power staffing policies still exist. If however the propulsion equipment does not require nuclear trained personnel, then the personnel costs will be significantly less. Reductions will occur in all of the engineering divisions, if relaxed maintenance practices are adopted. The Auxiliary Division will again see the MM rating and reductions in overall personnel. The Repair Division will also see a reduction in personnel.

The Supply Department will see a small reduction in support personnel. Most of the early reductions in the Supply Department came about from the advent of on-line transaction processing and CALS (SK and DK ratings.) Though the SH rating is a labor intensive service rating, the Navy has consolidated and modified traditional practices to allow reductions in this rating. The MS rating and associated non rated seamen and firemen personnel have decreased as a result of crew reductions.

The total enlisted manning requirements for the SC 21 are projected as 174 enlisted personnel as shown in Figure 5-1. Seventeen officers will be required aboard SC 21. The ensuing personnel costs are $9,394,187.99 for the enlisted personnel. Officer costs are projected at $1,793,631.69. The combined personnel costs are $11,187,819.68 (Figure 5-2).

3. Arguments and Ramifications

Scenario Three presents the brightest picture in terms of personnel costs. This scenario hinges on several technical factors proving fruitful. This assumes that autonomic technology will be successful and accepted as a viable operating medium for destroyers in the future by Navy leadership. Another option assumed is that the Navy will adapt a conditioned based maintenance system as opposed to the current periodic system that already has conditional factors mounted into it. The final strong assumption is that the Navy will relax but not eliminate its sometime burdensome bureaucratic policies. If the fleet adopts a relaxed maintenance policy similar to the Low-mix concept, then the shore maintenance facilities must be also taken into account when projecting the acquisition of the SC 21. If shore maintenance requirements are not taken into consideration prior to implementing the policy, then combat readiness will decrease from reduced material condition of the ships. This scenario could, in theory, repeat the problems experienced in the FFG 7 implementation with higher costs in terms of dollars and military readiness. The laser and PEM technology could theoretically become realities in the near future. Unfortunately, they also may not prove to be as wonderful for military application as designers claim.

The Navy also does yet not have an accurate manner of performing a cost-effectiveness analysis to see if these technologies are any better than existing mechanical gun and fossil fuel practices.

If the SC 21 in this scenario is produced and it requires nuclear trained personnel, the Navy will once again go into high volume nuclear training for enlisted and officer personnel. If the ship builders determine that PEM propulsion does not require nuclear trained personnel, then the costs will be even cheaper that anticipated, given the accuracy of the personnel requirement estimations. The disadvantage to using minimum-manned ships from an operator's standpoint is that personnel absences can severely hamper readiness and increase individual workload.

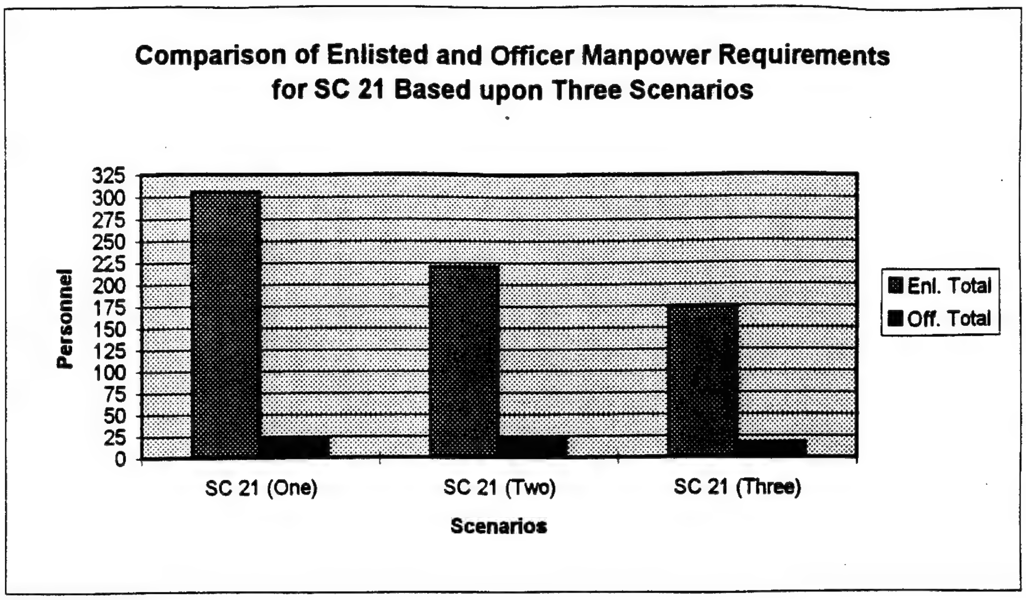

Figure 5-1 Comparison of Enlisted and Officer Manpower Requirements for SC 21 Based upon Three Scenarios.

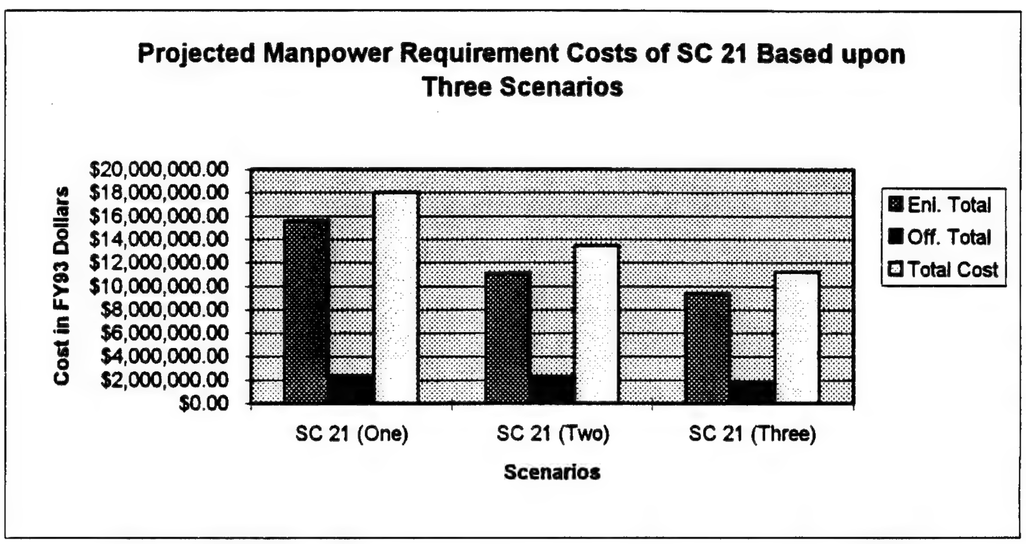

Figure 5-2 Projected Manpower Requirements Costs of SC 21 Based upon Three Scenarios.

E. WRAP UP

A comparison with recent destroyers assists in evaluating the projections of manpower requirements (Figure 5-3). The three projections decline according to the amount of progress in technology and removal of administrative burden. Personnel costs also decline over the series (Figure 5-4). None of the projections rival the reductions of the Autonomic Ship presentation manning predictions (Figure 5-5). A departmental breakdown of the personnel requirements and costs are listed in Figures 5-6 and 5-7. Simulated manning documents for each of the scenarios can be obtained from the author. The three projections in this thesis consider a wide variety of many naval organizational and operational practices. Some of these practices include the existing ship administrative structures, maintenance practices, warfighting modes, and training networks. The final consideration in determining these manpower requirements will involve viewing anticipated labor supply elements. The Navy is not expected to change its current practice of recruiting untrained personnel and "growing them into trained mariners." The Navy hierarchical officer and enlisted personnel structures are expected to remain in tact.

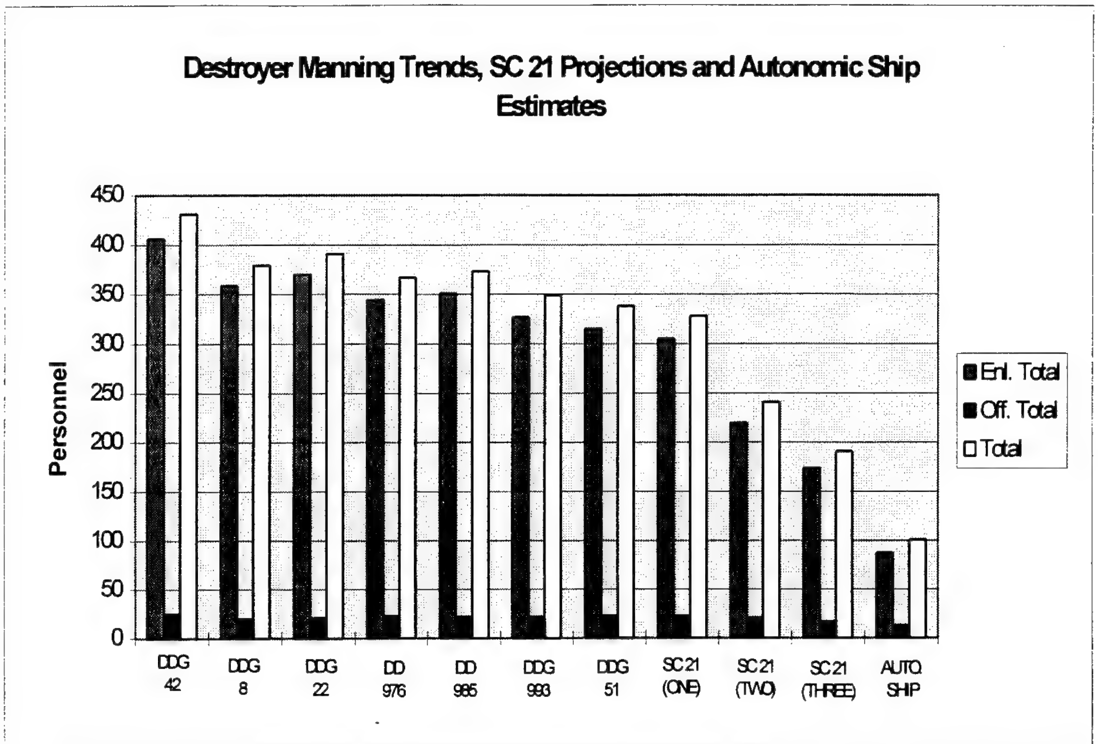

Figure 5-3 Comparison of Past Manpower Requirements and Three Projections of SC 21 Manning.

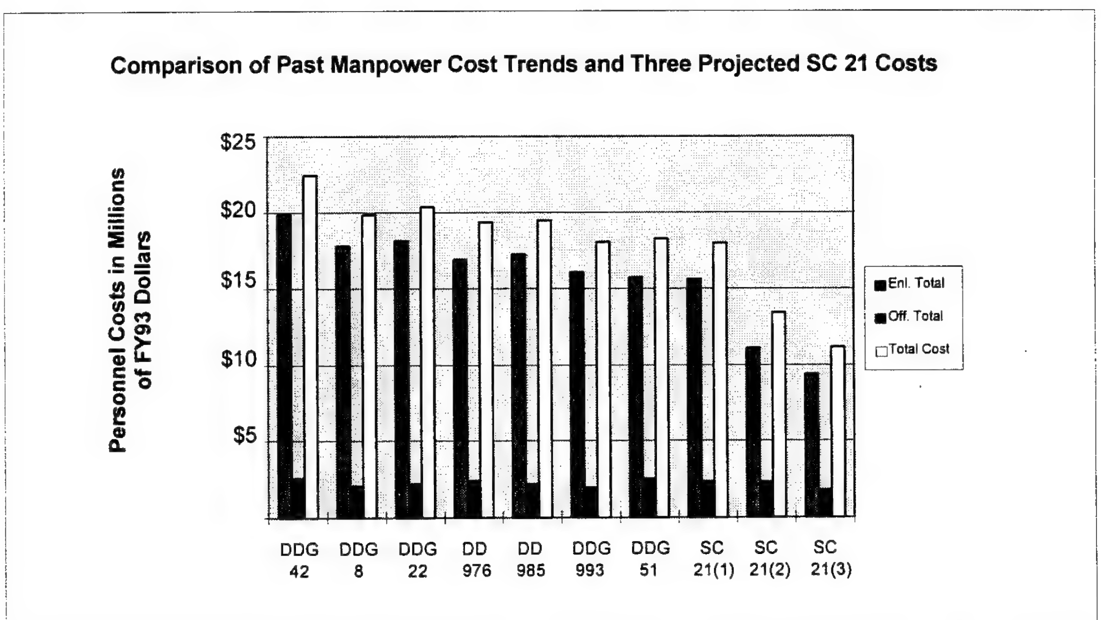

Figure 5-4 Comparison of Past Manpower Cost Trends and Three Projected SC 21 Costs.

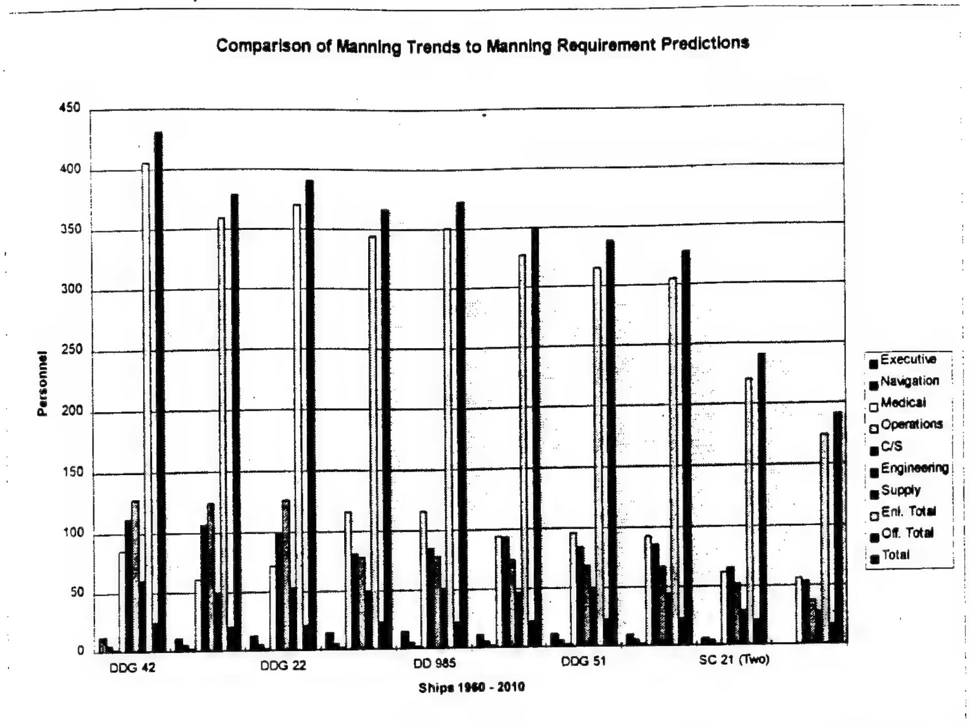

Figure 5-5 Comparison of Departmental Manning Trends to Predictions.

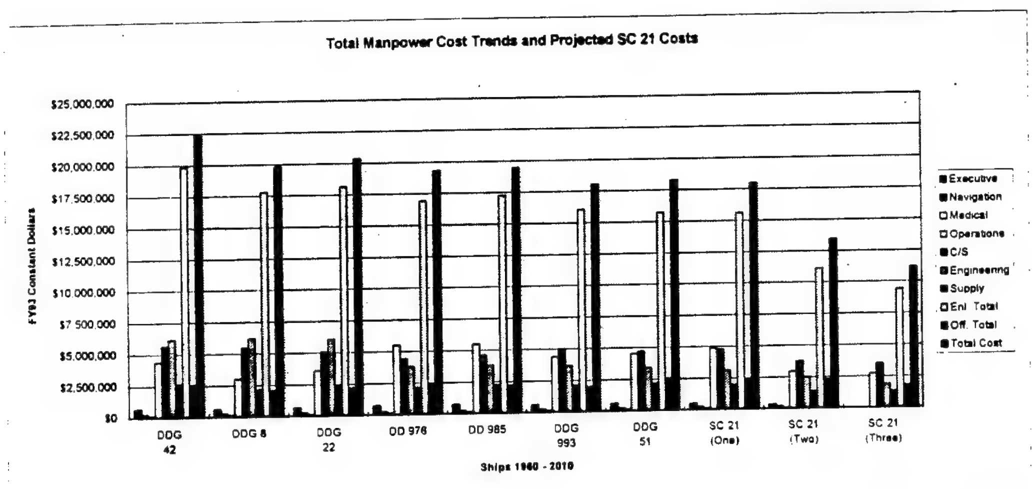

Figure 5-6 Comparison of Departmental Manning Costs to Predictions.

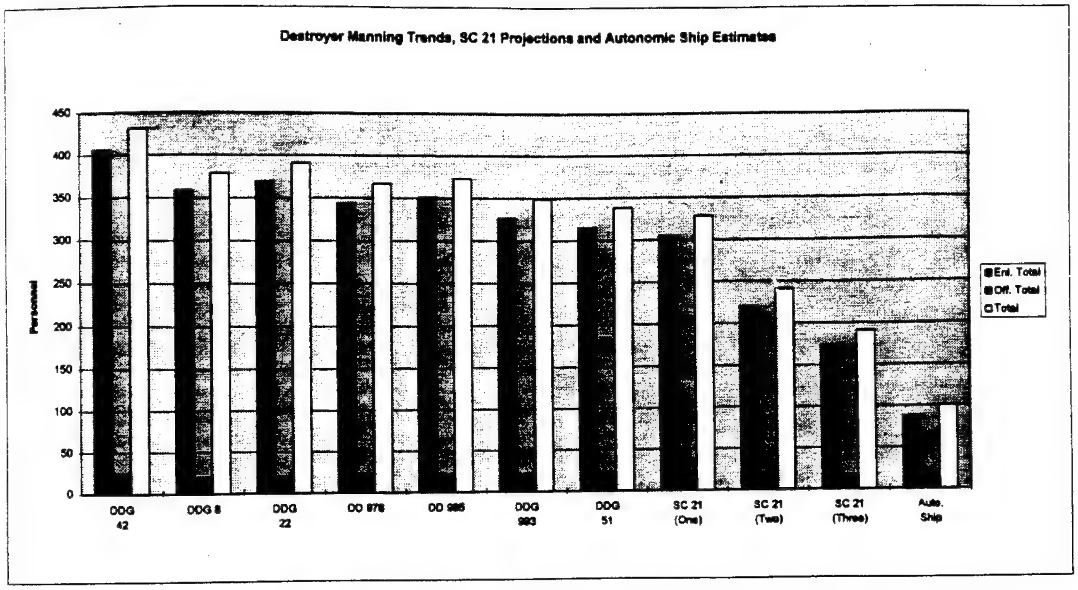

Figure 5-7 Comparison of Destroyer Manning Trends, SC 21 Projections and Autonomic Ship Estimates.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This thesis introduced a historical view of U.S. Navy Destroyers. The view centered on mission and technological advances as a background for discussing their implications for destroyer manpower requirements. It analyzes personnel trends of recent destroyer classes. The study includes some design and technological ideas proposed for the next generation destroyer. These ideas focused on implications for projecting manpower requirements. Three generic scenarios loom in the future for Navy planners that will determine the manpower requirements for the next generation destroyer. The individual ship requirements in turn have "macro" force level implications.

Ultimately, the manpower requirements of the next generation will hinge upon technology. Organizational constraints cannot be disregarded in this planning period. These constraints include corrective and preventive maintenance on equipment. They also include watch standing and facilities maintenance. The final organizational constraint is administrative support. The "paper work" is not likely to go away.

The analysis predicts that manpower requirements will decline with the next generation destroyer (Figure 6-1). This assumes that the ship will be built with a similar mission capability as the DDG 51. Estimates vary according to the degree of advanced technology by the acquisition point of the key ship systems.

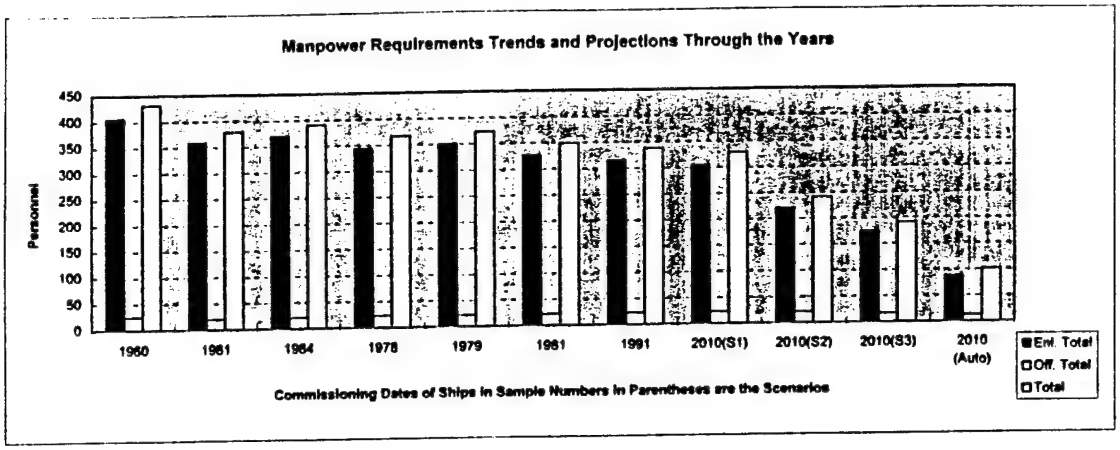

Figure 6-1 Manpower Requirements Trends and Projections Through the Years.

B. RECOMMENDATIONS

The Navy can anticipate technology reducing manpower requirements. The degree to which this will occur, however, is yet to be seen. The technology must become applicable in the fleet prior to seeing the fruit of reduced labor requirements. Before relaxing maintenance policies, the Navy must carry analyze pertinent material and operating data to evaluate the utility of the periodic maintenance employed by the fleet today. This system was employed to improve and maintain readiness. Abruptly stopping the existing maintenance programs or arbitrarily relaxing them could have serious degrading consequences. The organizational administrative burdens will probably never cease. Office automation has reduced the manpower formerly required to ensure efficiency in performing administration. The executive assistants (MA, NC, PC) serve useful purposes in easing administrative labor for a navy ship. Eliminating

these positions aboard a destroyer would put excessive burden on the officers and detract from overall combat effectiveness.

The anecdote of the FFG 7 saga, mentioned in Chapter V, should serve as a reminder of the pitfalls of arbitrarily assigning manpower requirements. It was design to cost. If SC 21 is design to cost also, these same risks could be at stake. The FFG 7 "fix" was relatively cheap compared to today's and tomorrow's projections. The stakes are high in terms of military readiness and naval service prestige. Naval Planners and engineers should remember that warships are not operated by licensed merchant mariners. Warships do not perform the same mission in the same environmental conditions as merchant ships. This statement does not imply that the Navy cannot employ any of the labor saving technology that merchants today already possess. The Navy should continue invest in labor saving technology and research.

Further analyses in this area of naval study could focus on key fiscal interrelationships of weapon platforms. The most obvious of the relationships are capital value, personnel requirement costs, and operations & maintenance costs. These costs can be analyzed in respect to mission and operational tempo. The analyses could yield quantifiable measures of effectiveness. These measures could be applied to all major fleet assets in the Navy order of battle.

The Navy has the potential to embark on landmark systems development (autonomic technology). Ships have increased in capability, fire power, and (anecdotally) reliability since the advent of the U.S. Navy. The IT

revolution is still opening up new possibilities for systems every day. The Navy should exploit as much technology as it can afford fiscally and militarily. The curious thing about computer technology is that computers are built and programmed by people. The technology should then ease the person's work load or help in decision making. Some person (or other device) must still feed the computer data to process. Finally, a person still has to act on the processed information.

LIST OF REFERENCES

Arnold, Richard R. and Barrie, Robert W. Analysis of Manning Decisions and Concepts Utilized for FFG-7 Class Ship. Masters Thesis, Naval Postgraduate School, Monterey, CA, 1980.

Binkin, Martin J., Military Technology and Defense Manpower, Washington: Brookings Institute, 1986.

Chief of Naval Operations (CNO) Staff, Ships Operational Characteristics Study, 1988.

Friedman, Norman, The Post War Naval Revolution, Annapolis: Naval Institute Press, 1986.

Huchting, George, RADM USN, "Lean & Mean Warship Design," U.S. Naval Institute Proceedings, 120/10/1,100 (Oct 1994).

Lovelace, Edward C., Smoother Sailing Ahead: "Integrating Information Technology Into the Surface Navy." Masters Thesis, Naval Postgraduate School, Monterey, CA, 1994.

Mairs, Lee, Project Manager of the Navy Billet Cost Factor Model, SAG Corporation, Interviews conducted January 1995.

Naval Surface Warfare Center Carderock Division (NSWC), Bethesda, MD. Video Presentation: The Autonomic Ship. 1993.

Navy Billet Cost Factor "Active Component Cost Estimation Model", Version 1.0 Operations Manual. Falls Church, VA: SAG Corporation, 1994.

OPNAVINST 3120.32B Subject: SHIP'S ORGANIZATION AND REGULATIONS MANUAL, 26 September 1986.

Polmar, Norman, The Naval Institute Guide to the Ships and Aircraft of the U.S. Fleet, fifteenth edition, Annapolis: Naval Institute Press, 1993.

Preston, Anthony, Warships of the World, New York: Jane's Publishing Inc., 1980.

Reilly, John C. Jr., United States Navy Destroyers of World War II, ed. Frank D. Johnson, (Poole, Dorset: Blandford Press, 1983).

Sargent, David, Rear Admiral, USN, Speech to the Surface Navy Association, Monterey, CA Chapter, Ingersoll Hall, November 1994.

Shishko, Robert. The Economics of Naval Ship Automation: "An Analysis of the Proposed Automation of the DE-1052." Santa Monica: Rand Corporation, 1975.

Tarpgaard, Peter T., Naval Surface Combatants in 1990's: "Prospects and Possibilities," Washington: U.S. Government Printing Office.

United States Naval History Division, Destroyers in the United States Navy, Washington: Naval History Division, 1962.

BIBLIOGRAPHY

Blake, Bernard ed., Jane's Radar and Electronic Warfare Systems, sixth edition 1994-95, Guildford: Biddles Ltd., 1994.

Cooper, Richard V.L., Military Manpower and the All-Volunteer-Force, Santa Monica: Rand Corporation, 1977.

Cooper, Richard V.L. and Roll, Charles Robert, Jr. The Allocation Military Resources: "Implications for Capital-Labor Substitution." Santa Monica: Rand Corporation, 1974.

Cooper, Richard V.L. and Rostker, Bernard. Military Manpower in a Changing Environment. Santa Monica: Rand Corporation, 1974.

Jordan, John, An Illustrated Guide to Modern Destroyers, New York: Prentice Hall Press, 1986.

OPNAVINST 5310.18A Subject: Ship Manpower Document/Squadron Manpower Document (SMD/SQMD) Development and Review Procedures, 16 April 1986.

Petty, R.T. and Archer, D. H. R., ed., Jane's Weapon Systems, second edition 1970-71, London: B.P.C. Publishing Ltd., 1970.

Rackham, Peter, ed., Jane's C^4I Systems, sixth edition1994-95, London: Butler and Tanner Ltd., 1994.

Sharpe, Richard CAPT OBE RN ed., Jane's Fighting Ships, ninety seventh edition 1994-95, London: Butler and Tanner Ltd., 1994.

Williamson, John, ed. Jane's Military Communications fifteenth edition 1994-95, Guildford: Biddles Ltd., 1994.

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